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LAKE ERIE DRAINAGE BASIN. A COOPERATIVE STATE-FEDERAL REPORT ON WATER POLLUTION

Public Health Service
Cincinnati, Ohio

1951

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For Clean Water -"One River, One Plan"

Lake Erie
DRAINAGE BASIN

A COOPERATIVE STATE-FEDERAL REPORT ON WATER POLLUTION

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FEDERAL SECURITY AGENCY

Public Health Service

56

SUMMARY REPORT ON WATER POLLUTION

Lake Erie Drainage Basin

(Area draining into Lake Erie between Ohio-Michigan and Pennsylvania-New York Borders)

Prepared by

FEDERAL SECURITY AGENCY
Public Health Service
Division of Water Pollution Control
Ohio and Tennessee Drainage Basins Office

1951

On the basis of information supplied by

Indiana Stream Pollution Control Board
Michigan Water Resources Commission
Ohio State Department of Health
Pennsylvania Sanitary Water Board,
State Department of Health

I

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II

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INTRODUCTION

The Federal Water Pollution Control Act, Public Law 845, passed by the 80th Congress in June of 1948, requires the Surgeon General of the Public Health Service to cooperate with other Federal agencies, with State and interstate water pollution control agencies, and with municipalities and industries in the preparation or adoption of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof, and improving the sanitary condition of surface and underground waters.

In developing these programs, due regard must be given to improvements necessary to conserve the Nation's waters for public water supplies, propagation of fish and aquatic life, recreational purposes, agricultural, industrial, and other legitimate uses.

Recognizing the fact that full technical information was not available to permit the development of such comprehensive programs immediately for most of the Nation's waters, the Public Health Service envisioned the development of these programs in two general phases. The first phase contemplated the development of a series of reports, consistent with presently available data, which would: provide a reference point for measuring progress; provide a guide to needed additional data; provide a basis for the logical development of comprehensive programs; provide a basis for approval of loans to States, interstate agencies and municipalities at such time as the Congress made available funds for this purpose; and serve to inform the public on the problem of water pollution and set forth suggestions for pollution control.

The collection of available data as of July 1, 1950, has been completed under the first phase of the program. Such data have been assembled with the cooperation of State and interstate water pollution control agencies. Through these agencies additional data have been obtained from other State officials, county and city officials and representatives of industry. Federal agencies also have been of great assistance. In order to make this information available at the earliest possible moment, these data are being presented in 15 summary-type reports covering the United States by major drainage basins. This report on the Lake Erie Basin is one of that series.

These summary reports present information about the ways our water resources are used, the pollution going into our water resources and the resulting damages, the benefits which may result from pollution prevention and abatement, the pollution prevention measures now in effect, and those required.

They are prepared in two parts. Part one considers the water pollution problems of the basin as a whole. Part two presents briefly the data for each of the several sub-basins of the major basin, including a list of projects now known to be needed for water pollution control.

Since the summary reports are based on data which are now readily available, these reports do not discuss or evaluate the most advantageous water uses as they are related to pollution control. Such considerations will be included as a part of the comprehensive water pollution control programs.

The deficiencies in data and the gaps in information indicated in these summary reports are as significant as the presentation of available facts and statistics. They indicate the work which still needs to be accomplished by water pollution control authorities for the preparation of comprehensive programs.

Data and knowledge now available are sufficient, however, to permit the immediate solution of many of the pollution problems within the Lake Erie Basin without awaiting the results of additional surveys and studies. The tabulations of pollution abatement projects which are included in Part Two of this summary report represent presently known needs. However, future studies and evaluations may result in some changes in the estimations of requirements.

A sincere effort has been made by all who contributed to this report to present a fair picture of the complex water pollution problems in the Lake Erie Basin and to present reasonable conclusions and recommendations. It is our hope that this report, as a step in the cooperative development of an ultimate comprehensive pollution control program, will help in safeguarding the water resources of the Lake Erie Basin.

Leonard A. Scheele

Surgeon General

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ACKNOWLEDGMENTS

The Public Health Service wishes to acknowledge the cooperation and assistance of those agencies and individuals that have contributed to the preparation of this report.

The water pollution control agencies of the States in the basin, including the Pennsylvania Sanitary Water Board of the State Department of Health, the Ohio State Department of Health, the Indiana Stream Pollution Control Board, and the Michigan Water Resources Commission, have furnished the data from which the various tables were prepared and other data and information contained in the narrative statements. These agencies have also reviewed the preliminary draft of the report and have offered valuable comments which have been incorporated.

Federal agencies from which assistance or data were obtained include the Corps of Engineers, Department of the Army, and the Fish and Wildlife Service and Geological Survey, Department of the Interior.

There is also acknowledged the assistance of other State agencies, including the Department of Natural Resources of the State of Ohio and the Franz Theodore Stone Institute of Hydrobiology, and individuals interested in water resources development and conservation, who have contributed directly or indirectly to the report through other agencies.

SUMMARY

For the purposes of this report the Lake Erie Basin is defined as that area draining into Lake Erie between the Michigan-Ohio border and the Pennsylvania-New York border. In addition to portions of Ohio and Pennsylvania, this area includes that portion of Indiana and Michigan tributary to the Maumee River and small areas in Michigan and New York which drain to Lake Erie through Ohio and Pennsylvania, respectively. The total drainage area of the basin is about 14,065 square miles.

The basin lies in a glaciated area and the topography is characterized by low relief varying from flat, poorly drained areas to gently rolling hills.

The location of the basin with respect to lake transportation and its position between iron ore and coal deposits have combined to make the cities important as transportation and industrial centers. Slightly over 15 percent of the total population is employed by manufacturing industries. Approximately 70 percent of the population employed by industry is engaged in the primary metal, fabricated metal, machinery, transportation equipment, and rubber industries. The topography, soils, and climate are well suited for agriculture and this activity forms an important part of the economy of the basin.

The 1940 population in the basin was about 3,150,500.

Water uses in the basin include public and industrial water supplies, navigation (principally on Lake Erie), some power development, recreation (including boating, bathing and fishing, principally in waters along the shore line), irrigation and final waste disposal. A population of 2,396,300, residing in 136 municipalities and other population centers, is served by 51 municipal water treatment plants using surface waters as a source. Of these plants, 22 take water from Lake Erie and the remainder obtain supplies from tributary streams.

Wastes are discharged from 206 centers of population and from 187 industries through sewers not connected to municipal systems. Thus, a total of 393 sources of existing or potential pollution are listed by the State water pollution control agencies of this basin. Included with those sources which may be considered as having only potential significance are 40 communities having no comprehensive public sewerage system and several small industries for which it has not been determined that treatment of waste is required. The 206 population centers include only 201 separate entities. For convenience in tabulation Cleveland is divided into four population centers and each of two other municipalities is divided into two population centers, on the basis of separate sewerage systems. Classified on the basis of 1940 populations, 74 municipalities have populations in excess of 2,500, 56 have populations from 1,001 through 2,500, 48 have populations from 501 through 1,000, and 28 have populations of 500 or less.

The total organic waste load discharged from 172 municipal sources of pollution is estimated at 1,474,000 equivalent population, and the organic waste load from 107 of the industrial sources is estimated at 941,800 equivalent population. Because necessary data are not available, the organic waste load from 34 municipal sources and 47 industrial sources have not been estimated. Twenty-two of the 34 municipal sources do not have comprehensive public sewer systems.

Inorganic wastes, not measurable by population equivalent, are discharged from 61 industrial plants, 45 of which also discharge organic wastes. The types of wastes from 17 industrial plants have not been determined.

The combined population equivalent waste load discharged to the waters of the basin from industries and municipalities for which estimates are available is approximately 2,416,000. Of this amount about 1,603,000 is discharged in the vicinities of Toledo and Cleveland, Ohio, and Erie, Pa.

The extent and effect of pollution by silt from both agricultural and nonagricultural lands have not been determined; however, there is strong evidence pointing to siltation and pollution of spawning areas as major factors causing a decline of the more desirable species of fish.

Water pollution in this basin damages waters used for municipal and industrial water supplies, and for fishing, bathing and other recreational uses. These damages include public health hazards, restrictions in use of water for legitimate purposes, increased cost of water treatment, economic losses in resort areas, and reduction in aesthetic values. These damages may be the result of bacterial pollution, deoxygenation, toxicity, color, taste and odor producing substances, or excessive concentrations of inorganic wastes. However, there are no interstate problems of any great significance.

Treatment facilities are provided for 99 of the 206 sources of municipal pollution; 29 of these receive primary treatment and 70 receive secondary treatment. Approximately

86 percent of the population served by sewers is connected to these treatment plants. Of this population served by treatment plants, about 59 percent is served by plants which are inadequate.

About 35 percent of the total population served by sewers is connected to treatment plants which are satisfactory. It is significant that of the total population reported as being served by treatment plants which are inadequate, about 90 percent is included in the combined total connected to the Toledo, Ohio plant, two Cleveland, Ohio plants, and the Akron, Ohio plant. Improvements are under construction at Akron. Plans have been approved for improvements at Toledo and one Cleveland plant, and plans are under preparation for the other Cleveland plant. Of the 142 municipal sources of pollution listed as requiring new plants or some form of improvement to existing plants, 49 have populations exceeding 2,500, of which one exceeds 400,000, two exceed 300,000, and another exceeds 250,000; 43 have populations from 1,001 through 2,500; 38 have populations from 501 through 1000; and 12 have populations of 500 or less.

Treatment facilities of some type have been reported for 70 of the 187 industries listed as sources of pollution. Twenty-eight of the industrial waste treatment plants are reported to be inadequate to meet present needs. One hundred and seven of these industries provide no treatment for their wastes. No determination has been made on the existence of treatment facilities at the other ten.

Five municipal waste treatment plants were constructed between 1946 and 1949 inclusive. These plants were designed to serve a combined population of about 40,000. During this same period, 17 industrial waste treatment plants were provided.

On the basis of existing data new treatment plants are required to serve 91 municipal sources of pollution and 96 industrial sources of pollution. Enlargements or additions to existing facilities are required to serve 41 municipalities and 22 industries. Existing treatment facilities serving 10 municipalities and 11 industries should be replaced. Requirements have not been determined at 3 municipal and 23 industrial sources of pollution. At this time 61 municipal and 35 industrial waste sources require no project for pollution abatement. Corrective measures have been initiated for 60 municipal and 17 industrial sources.

Effective State legislation is necessary to promote pollution abatement. Much progress has been made both with municipalities and industries, through cooperative action such as field contacts and consultation service which has resulted in corrective action without the necessity of formal orders. However, the water pollution control program in Ohio would be strengthened by legislation more comprehensive than that which now exists.[1]

The capital cost of facilities required for abatement of pollution from municipal and industrial sources is influenced by many factors. These include degree of treatment required, feasibility of connecting industrial plants to municipal systems, development of methods for treating industrial wastes, and extent of requirements for interceptors. A detailed analysis of cost based on thorough consideration of all factors is not feasible at this time. An approximate estimate of cost, based on average conditions, has been made for the purpose of showing the relative magnitude of requirements in this basin as compared to other basins. This estimate indicates that the capital cost for treatment works and required interceptors will be between $50,000,000 and $70,000,000.

[1]Comprehensive water pollution control legislation was enacted by the Ohio legislature in June 1951.

CONCLUSIONS

1. The water resources of the Lake Erie Basin have been an important factor in the industrial and municipal growth in the area. Advantages of location with respect to the Great Lakes navigation system is the outstanding characteristic contributing to this growth. Use of water resources for commercial fishing is also important. Appreciated fully only in the absence of an adequate supply are the vital water needs for municipal, industrial, and livestock water supplies. Recreational uses of the water resources, including bathing, sport fishing, and boating, are enjoyed on a large scale, are important to the health and well being of the public, and have contributed significantly to the development of the area.

2. Pollution in the basin causes damages to legitimate water uses, restricts full use of the water resources, and results in local nuisances.

3. Public health hazards in this basin are created by contamination of public water supply sources and water areas used for recreation. The necessity for continuing the use of these sources, regardless of their excessively polluted condition and the tendency of the public to ignore dangerous indices of pollution in bathing waters intensify these hazards.

4. Fluctuations in fish populations in this basin have been of major concern to commercial fishing interests. There is strong evidence pointing to siltation and pollution of spawning areas as major factors adversely affecting fish population.

5. Available basic data on the sources of pollution and their damaging effects in critical areas, supplemented by data to be obtained as specific projects are initiated, permit proceeding with a sound program of pollution abatement. Concurrent planning of a comprehensive program for pollution abatement is necessary.

6. New or improved waste treatment facilities are needed for 116 municipalities served by public sewer systems and for 129 sources of industrial wastes now discharging directly to the watercourses. There are also 26 communities with no comprehensive sewer systems which the States have indicated as needing treatment in their long range pollution abatement programs. The needs at three municipalities, two with comprehensive public sewerage systems and one without, and at 23 industries are not now known.

7. Although the data show little progress in the construction phases of waste treatment facilities in the post-war years of 1946 to 1949 inclusive, substantial progress has been made in initial actions such as cooperative contacts by State water pollution control agencies, issuance of abatement orders, preparation of plans, promotional and educational work, and similar activities.

8. Lack of adequate water pollution control legislation in Ohio is hampering the pollution abatement program.[2] Legislation in other States has not imposed any obvious deterrents to their control programs within the Lake Erie Drainage Basin. There are no interstate problems of any great significance.

9. The efficiency of waste treatment plants is greatly reflected by the quality of operation. Maintenance of high quality operation will assure securing of the maximum benefits from investments in waste treatment facilities. Approximately 40 percent of the existing sewage and industrial waste treatment plants in the basin are inadequate from a capacity standpoint while less than 14 percent are receiving inadequate operation. That so few sewage treatment plants are in the latter category reflects credit to State and local authorities responsible for supervision of operation.

10. An important factor in a pollution abatement program is the problem of financing the necessary promotion activities, field studies, and research, as well as the planning and construction of abatement works.

11. A necessary function of any pollution control program is that of keeping the public informed on the needs for and benefits of pollution abatement.

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[2]Comprehensive water pollution control legislation was enacted by the Ohio legislature in June 1951.

RECOMMENDATIONS

It is recommended that: 1. Municipalities and industries proceed with the construction of pollution abatement works necessary to restore and preserve the essential water uses of the basin.

2. The resources of the State water pollution control agencies be maintained at a level which will permit them to secure additional significant data on sources and amounts of pollution, treatment requirements and water quality objectives, as may be necessary to continue the development of a coordinated water pollution control program consistent with the needs of the basin.

3. Informational programs, designed to show accomplishments and to tell the public about the damages accruing from pollution and the benefits to be derived from its reduction, be continued and expanded.

4. Industrial, educational and governmental agencies expand and coordinate their research activities toward improving present industrial waste treatment methods and developing new methods for those wastes for which there is now no known practical treatment process.

5. Methods be developed to facilitate financing of municipal waste treatment facilities where such assistance is needed. The assumption of the financial responsibilities by the beneficiaries should be promoted.

6. Comprehensive water pollution control legislation be adopted by the State of Ohio.[3]

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[3]Comprehensive water pollution control legislation was enacted by the Ohio legislature in June 1951.

LOCATION MAP

Lake Erie Drainage Basin

GENERAL DESCRIPTION

Historical Background

The story of the region around Lake Erie forms an important chapter of American history. The area figured in many incidents in the early days of the white man's civilization on this continent. According to the record, Jolliet was the first white man to see Lake Erie. His discovery took place in 1669. Ten years later, LaSalle built and launched a ship above the Falls at Niagara and sailed from one end of Lake Erie to the other, thus leading the way for the countless ships that have since navigated that important waterway.

The lake region was fought for and controlled in turn by the Indians, French, British, and Americans. Since the War of 1812, the southern shore has remained under American control. The Rush-Bagot Treaty of 1817 officially ended the strife between the Canadians and Americans and paved the way for the rapid development of the area.

Physical Characteristics

Lake Erie is fourth in size among the five Great Lakes. With an area of about 9,940 square miles, the lake is some 240 miles long and varies in width up to 58 miles. Relatively shallow, Lake Erie has a mean depth of 90 feet, and its deepest soundings are only about 210 feet.

The Great Lakes form a natural frontier area between Canada and the United States. On the northern shore of Lake Erie lies the southernmost part of Canada. On the western, southern, and eastern shores, stretching from Detroit to Buffalo, are the States of Michigan, Ohio, Pennsylvania, and New York.

That part of the Lake Erie Drainage Basin covered by this report is limited to the portion which drains into Lake Erie between the Ohio-Michigan border and the Pennsylvania-New York border and includes an area of about 14,065 square miles. A major portion of this area, about 11,660 square miles, lies in Ohio, and comprises about one-fourth of the total area of that State. An area of about 1,260 square miles in Indiana drains to Lake Erie through the Maumee River. Another area of about 540 square miles in Michigan also lies in the Maumee River watershed. About 50 square miles in southeastern Michigan drains across the Ohio State boundary and into Lake Erie by way of the Ottawa River, sometimes locally called Ten Mile Creek. An area of approximately 515 square miles in Pennsylvania is included in the Lake Erie Basin. A small area of about 38 square miles in extreme western New York drains into Twenty Mile Creek, which flows westward into Pennsylvania and thence northward into Lake Erie.

The divide separating the Lake Erie and Ohio River Drainage Basins is generally low. Near Fort Wayne, the ridge has an elevation of only about 750 feet above sea level and high floods there on the Maumee River spill over and drain into the Wabash River. The divide runs south and east from the location near Fort Wayne until it reaches a point less than ten miles below Lake St. Marys. There it turns northeastward and angles up toward the Lake shore line, reaching a point only about 10 miles south of the shore at the Pennsylvania-New York boundary. The divide rises irregularly toward the northeast, reaching an elevation of 1,040 feet above sea level at the Ohio-Pennsylvania State line. The streams in the eastern part of the basin are shorter and steeper than the streams draining the lower, flat lands near the western end of Lake Erie

The Lake Erie Basin contains portions of two major physiographic provinces, the Central Lowland and the Allegheny Plateau. The lower portion of the Maumee River flows through the Lake Plains section of very flat topography. The upper reaches of the Maumee are in the Till Plains of the Central Lowland. In the northeastern part of the Lake Erie Basin the short streams rise in the rolling terrain of the glaciated portion of the Allegheny Plateau. These streams have cut narrow gorges in the plateau and have relatively steep slopes until they reach the narrow band of the flat Lake Plains which they cross before entering Lake Erie.

The Lake Erie Basin, as considered in this report, is divided into four sub-basins. These sub-basins, with their respective drainage areas, are as follows: the Lake Erie Shore Line and Minor Tributaries Sub-Basin, 5,175 square miles; the Maumee River Sub-Basin, 6,656 square miles; the Sandusky River Sub-Basin, 1,421 square miles; and the Cuyahoga River Sub-Basin, 813 square miles.

Climate-Hydrology

Lying between the 40th and 42nd parallels of north latitude, the Lake Erie Drainage Basin is in the Temperate Zone. The area may be considered a fairly distinctive climatic province largely because of the ameliorating effects of the extensive adjacent water area of Lake Erie. The land near the lake enjoys a much more even

climate than do some areas of the more southern, but inland, Ohio River Basin. The growing season is longer near the shore than along the divide separating the Lake Erie and Ohio River Basins. At Put-in-Bay in the Bass Islands there are, on the average, 201 days between the last killing frost in the spring and the first killing frost in the following fall. At Bucyrus, 70 miles to the south, and situated right on the Lake Erie-Ohio River Divide, the growing season has an average length of only 154 days.

Average monthly temperatures in the basin range from the 20's in January to the low 70's in July. Some representative locations with their average recorded Fahrenheit temperatures for January and July are as follows: Toledo, 26.9°, 74.0°; Fort Wayne, 26.7°, 74.1°; Cleveland, 28.3°, 72.4°; Akron, 27.2°, 72.9°; and Erie, Pa., 27.8°, 71.8°

Rainfall is abundant and fairly evenly distributed throughout the year. Mean annual precipitation, as recorded at 36 weather observation stations scattered over the basin, varies from 28 to 40 inches. The average for the basin is 34.7 inches per year. The rainfall at stations along the southern divide averages considerably more than at those locations along the shore. To illustrate, Catawba Island has a mean annual rainfall of 28.2 inches, while Bucyrus has 38.4 inches. Many of the weather stations have maintained rainfall records for as long as 50 years.

The discharge through the Niagara River near Buffalo has averaged 193,000 cubic feet per second over a period of 44 years. This does not include any flow diverted from the lakes above this point for such uses as the Chicago Sanitary and Ship Canal or Welland Canal in Ontario. Only about 20,000 cubic feet per second of runoff are contributed by the drainage area of Lake Erie itself. The remaining flow of 173,000 cubic feet per second enters Lake Erie through the St. Clair River from the upper lakes.

Economic Development

The strategic location of the basin with respect to water transportation and natural resources in other areas, combined with favorable water supplies, climate, and soil, accounts for its rapid growth and development in the past century.

Many of the cities in the basin are highly industrialized with diversified manufacturing. Their products include processed foods, textiles, wearing apparel, lumber and wood products, furniture, paper and allied products, printed materials and publications, chemicals, petroleum and coal products, rubber products, leather goods, stone and clay products, glass products, primary metals, fabricated metal products, machinery, electrical equipment, transportation equipment, and miscellaneous other products. Slightly more than 15 percent of the total population in the basin is employed by these industries. The predominant industries are those producing rubber, primary metal, fabricated metal, machinery, electrical equipment and supplies, and transportation equipment. These major industries employ more than 70 percent of the people engaged in the manufacturing industries.

The rural areas are highly developed for agricultural use. Due to the moderating influence of the lake on temperature changes, the area is well suited for growing fruit. Consequently, the area is noted for its fine vineyards and orchards.

Recreational developments, especially along the lake shore, are of important economic significance.

Commercial fishing is practiced extensively in Lake Erie. Fluctuations in fish population, particularly of the more desirable species, have been of considerable concern to commercial fishing interests for many years. The average reported annual catch for the past 20 years has been about 41 million pounds. From 50 to 60 percent of this catch is reported by the two States bordering on the lake in this basin. (Ref. Bulletin 144, Dept. of Natural Resources, Division of Wildlife, State of Ohio.)

The 1940 population in the basin was about 3,150,500. This represented about 2.4 percent of the nation's total population. The 1940 population in municipalities listed as sources of pollution was about 2,385,800, or 75 percent of the total population in the basin.

USES OF WATER RESOURCES

Use is made of the waters of Lake Erie and its tributary streams for navigation, domestic, industrial and livestock water supply, fish and wildlife propagation, recreation, and final waste disposal.

Commercial navigation on tributary streams above lake water level is practically nonexistent. The lower portions of the Maumee and Cuyahoga Rivers and the shipping lanes of Lake Erie are parts of one of the Nation's most important navigation systems. One of the principal factors promoting the rapid industrial and commercial development of the area has been the availability of lake transportation. From an economic standpoint, navigation is probably the most important water use in the basin.

There are 22 domestic water supply treatment plants in the basin which obtain raw water from Lake Erie. These supplies serve a total population of about 1,825,200 in 103 communities. There are also 29 domestic water supply treatment plants which obtain raw water from surface streams of the basin. These supplies serve a total population of 571,100 in 33 communities. Thus, surface sources supply water to 51 municipal treatment plants which serve a combined population of 2,396,300 in 136 communities. In addition to the industries which use water from municipal systems there are many which have private systems which use surface water as a source. The availability of an unlimited supply of water is one of the major factors which make the lake shore area attractive to process industries.

Although the raising of livestock is not the primary agricultural activity in the basin, it is of considerable importance, and the use of surface streams for livestock water supply is widespread. Surface streams are also of importance for the propagation of wildlife and game fish.

The use of Lake Erie for recreational purposes is extensive. Summer homes, beach resorts and bathing areas are found all along the shore line. Wide, sandy beaches and a gently sloping lake bottom near the shore make many of the bathing areas especially attractive. The area in the vicinity of Sandusky, Ohio, is highly developed for recreational uses. East Harbor and Cedar Point have been popular resorts and bathing areas for many years. Eight public bathing areas serve metropolitan Cleveland, while other public beaches are located at various points along the entire shore line. In all there are some 25 public beaches and many other areas serving the densely populated urban developments along Lake Erie. It has been tentatively estimated that more than 1,000,000 bathers use the Cleveland beaches each season, while at Cedar Point maximum daily bather counts have exceeded 7,500. Boating and fishing are also important recreational uses of the lake.

Streams of the basin are used for recreational purposes, although their use is not so extensive as that of the lake. The principal recreational use of the streams is game fishing.

As indicated in the previous section, commercial fishing in Lake Erie is an important activity. This industry is most active in the eastern and western ends of the lake.

Lake Erie and its tributaries are used to receive the domestic and industrial wastes from the sewers of 206 population centers and from 187 industries having separate sewer outlets. The utilization of surface waters for disposal of the final effluents from industries and municipalities, after adequate treatment, is a very valuable and necessary water use.

POLLUTION CONTRIBUTED TO WATER RESOURCES

The pollution load contributed to Lake Erie, or to its tributary streams, by municipal sewerage systems is indicated by data in Table A. For the purpose of developing this and subsequent tables, population centers such as incorporated or unincorporated municipalities, other legal bodies such as sanitary districts, significant institutions, and other population centers which may be considered as unit sources in studies of stream pollution, have been listed as municipalities. In this report, the city of Cleveland has been considered as four separate sources of municipal wastes. The city is served by four sewerage systems; one system discharges to Lake Erie to the west of the city, another to the lake east of the city, a third to the Cuyahoga River upstream from the city, and the fourth to the Cuyahoga River through numerous outfalls within the city. To permit correlation of the data presented by various tables contained in the report, the portion of the city served by each of the four sewerage systems has been considered a separate source of pollution.

There are 206 municipalities, as defined above, which have been reported by State water pollution control agencies as having pollution potential or now contributing pollution to Lake Erie or to its tributary streams. The population equivalent of wastes from 172 of these municipalities, which have an estimated combined population served of about 2,755,000, is estimated at 1,474,000. Of these 172 municipalities, 18, with a combined population of about 21,900, have no comprehensive public sewerage systems. Population equivalent data for wastes discharged by 34 communities, with an estimated combined population served of about 49,000, have not been reported. Many of these latter communities are of minor significance from a pollution standpoint and detailed population equivalent data are not required to effect pollution abatement where such may be necessary. Twenty-two of these communities, with a population of about 11,300, have no comprehensive public sewerage system.

Classified on the basis of 1940 populations, 74 municipalities have populations in excess of 2,500. Fifty-six have populations from 1,001 to 2,500; 48 have populations from 501 through 1,000; and 28 have populations of 500 or less.

Table B lists industries in the basin which discharge wastes to Lake Erie or its tributary streams through outlets not connected to municipal systems. The table lists a total of 187 such industries. Of these, 107 discharge an organic waste load with a population equivalent of approximately 941,800, and 47 discharge organic wastes with an undetermined but reportedly minor population equivalent. Of the 154 industrial plants which produce organic wastes, 45 also produce inorganic wastes. Another 16 plants produce industrial wastes which are of inorganic type only. The types of wastes discharged by 17 plants are undetermined, but are reported to be of minor significance from a population standpoint.

The domestic and organic industrial waste load for which population equivalent data are available has a total combined population equivalent of about 2,416,000. Of this total, about 685,000 population equivalent is discharged to Lake Erie and the lower portion of the Cuyahoga River in the Cleveland area; about 500,000 population equivalent is discharged to the lower portion of the Maumee River at Toledo, and about 418,000 population equivalent is discharged to Lake Erie in the vicinity of Erie, Pa. Thus, approximately 66 percent of the above total is discharged in these three areas.

The food processing and petroleum industries discharge the greater part of the organic industrial waste load for which population equivalent estimates have been obtained. Major inorganic wastes are waste acid from steel plants and toxic wastes and taste and odor producing substances from chemical and coke plants.

It is reported that considerable damage occurs to the waters of the basin from silt. Data have not been obtained to indicate the full significance of this type of pollution.

Table A. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	172[1,2]	2,755,394[1]	1,474,054[1]
Having population data available (Data on pollution load to watercourse incomplete or not available)	34[3]	49,055[3]	Not applicable
Total	206	2,804,449	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

**Includes estimates of industrial wastes discharged into municipal sewerage systems. In some instances the estimates are incomplete.

[1]These 172 population centers include only 167 separate entities. Cleveland is divided into 4 population centers and each of two other municipalities is divided into two population centers. This breakdown is made for convenience in tabulation because of the division of municipalities into separate sewer districts.

[2]Includes data for 18 communities having no comprehensive public sewerage systems. These communities have an estimated combined population of 21,935.

[3]Includes data for 22 communities having no comprehensive public sewerage systems. These communities have an estimated combined population of 11,345.

Table B. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	107**[1]	941,788
Producing organic wastes	47[2]	Undetermined
Producing inorganic wastes	61	Not applicable
Producing wastes of undetermined type	17	Undetermined
Total	187[3]	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Includes 38 plants also producing inorganic wastes.

[1]Includes 18 plants whose only organic wastes are sanitary wastes. These sanitary wastes have a combined population equivalent of about 6,666.

[2]Includes 7 plants also producing inorganic wastes.

[3]Total adjusted to correct for duplication noted in footnotes marked thus, ** and [2].

DAMAGES TO WATER RESOURCES FROM POLLUTION

Pollution causes damage to a number of legitimate water uses in the basin. The amount of damage varies with the degree of pollution and depends upon the extent to which existing water uses are affected and potential water uses are held in abeyance by unsatisfactory water quality. In some areas of the basin, streams are undamaged by pollution either because of the absence of pollution sources or because the amounts of wastes discharged to the streams do not exceed their pollution absorbing capacities consistent with other water uses. In other instances, however, all existing water uses along many miles of a stream are damaged and other uses prohibited by the excessive pollution load with which the stream is burdened. Water use damages result from bacterial pollution, deoxygenation from organic pollution, toxicity, acid conditions, increased hardness, chloride content, or the presence of color, odor, or taste producing substances.

One of the most serious pollution problems in the basin is the damaging effects of pollution on bathing. Bacterial pollution from inadequately treated domestic sewage and combined sewer system storm water overflow in the vicinity of Cleveland is seriously damaging the use of Lake Erie waters in this area for bathing. This problem is particularly significant because of the extensive development of recreational facilities, both public and private, and because of the need for adequate and safe recreational facilities by the residents of the densely populated urban areas along the shore line. Studies on the Cleveland beaches conducted by the city of Cleveland during the summer of 1949, indicated that the sanitary quality of those waters was much below any currently recommended public health standards. It is believed that the Cleveland area is the most seriously affected, although limited data on other beaches indicate that some of them have waters of questionable sanitary quality.

Damages by pollution to public water supplies along the shore line are overcome to a large extent by extension of intakes into the lake. Generally, the quality of water at the lake intakes is well above minimum standards. Some of the streams used for public water supplies in the Maumee Sub-Basin are polluted to the extent that the quality of the water is below that considered desirable by present public health standards. Three of the four public water supplies using the Sandusky River as a source have intakes below sources of pollution, and two of these are located below cities which provide no waste treatment.

Instances of damages to other water uses occur throughout the basin. Industrial and livestock water supplies and recreational uses are adversely affected by pollution on the main stem of the Maumee River and many of its tributaries, and nuisance conditions exist in some locations. Similar conditions are found in the other sub-basins and on the minor tributaries.

BENEFITS RESULTING FROM POLLUTION PREVENTION AND ABATEMENT

Benefits resulting from stream pollution abatement will accrue to municipal, industrial, and livestock water supplies, and to the general public from the standpoint of public health, recreation, and aesthetic values.

Benefits to municipal water supplies will include reduction in the health hazard from use of water supply sources which are seriously polluted, will reduce treatment costs, and may prevent the future necessity of changing sources of supplies.

Water supplies for livestock will be substantially improved. Since most of the watershed outside of the metropolitan areas is highly developed for agriculture, these benefits are very significant.

Pollution abatement will reduce public health hazards and promote the general welfare of the public. General benefits to the public include both tangible and intangible benefits. These will include preservation and restoration of recreational areas for boating, bathing, fishing, and other uses. The commercial, public, and private recreational developments, and the recreational demands, are such that use of the water resources for these purposes will persist, as has been demonstrated, even though the water quality is unsuitable. Some of the uses under these conditions, though highly undesirable because of the health hazards involved, may continue through ignorance, carelessness, or on the assumption by some of the public that the recreational enjoyment or other benefits from such uses outweigh the actual health risks involved. Pollution abatement will not only reduce the hazards but will permit increased use of this natural resource. This is especially true with respect to the use of the Lake Erie waters for bathing. The lake shore offers almost unlimited opportunity for recreation and bathing to the residents of many highly industrialized centers of population. Pollution control will permit the continuation and expansion of this water use which because of its proximity to so many potential users is of considerable tangible monetary value.

Pollution abatement will be of benefit to industry by improvement of industrial water supplies and by permitting disposal of final effluents, properly treated, to the streams from present, expanded or new industries.

In view of the rapid increase in industrial development in the basin, the present unsatisfactory water quality in many areas demonstrates the need for proper municipal and industrial waste treatment in order to retain and increase the benefits from water resource uses and to abate existing and prevent future nuisance conditions.

POLLUTION PREVENTION MEASURES IN EFFECT

Tables C and E contain data relative to existing municipal sewage treatment plants. Of the 206 municipal sources of pollution, 29, or 14 percent, provide primary treatment; 70, or 34 percent, provide secondary treatment; and 107, or 52 percent, discharge untreated sewage to the surface waters of the basin. However, on the basis of the population served by municipal sewer systems, only 14 percent discharge untreated sewage into the waters of the drainage basin, while about 31 percent of the sewered population is served by primary treatment plants and 55 percent is served by secondary treatment plants. Included in the total number of municipalities which provide no waste treatment are 40 communities which have no comprehensive public sewerage systems. These 40 communities have an estimated combined population of 33,300. This population figure has been used as the population served by sewerage systems for these communities to facilitate tabulation. While the inclusion of this population data in lieu of more accurate population served data causes error on the high side, the error is a small percentage of the total population served by sewerage facilities.

The data do not include information concerning the total domestic and industrial waste load discharged to municipal sewerage systems; therefore, there is no accurate estimate of the percentage reduction of waste load by present municipal sewage treatment plants. Furthermore, as indicated by Table E, 32 of the 77 existing municipal treatment plants are reported to be inadequate and do not give the percentage reduction in waste load which may ordinarily be expected from primary or secondary treatment plants. Although the population connected to these inadequate plants represents about 59 percent of the total served by treatment works, several of the larger cities are in the planning and construction phase of enlarging existing overloaded facilities. Cleveland, for example, has work under contract and planning under way which, when completed, will increase the capacity of existing treatment plants and will also intercept and treat the sewage now entering the lower stretches of the Cuyahoga River. Also plans have been approved for improvements at Toledo and improvements are under construction at Akron. Planning is proceeding on several other municipal treatment plants along the lake shore as well as on the tributary systems.

Table D classifies the industrial sources of pollution according to type of industry and shows the number of industrial plants of each type which provide treatment for their wastes. The predominant industry having separate outlets for discharging wastes directly to receiving waters is the food processing industry. Other industries include those producing chemical and allied products, fabricated metal products, primary metals, petroleum and coal products, rubber products, paper and allied products, textile mill products, and leather products. Other industries of miscellaneous types also contribute a significant amount of pollution. Table D shows that 70 of the 187 industrial plants listed as significant sources have some type of waste treatment while no treatment is provided at 107 plants, and the status of waste treatment at 10 more is undetermined.

Table E classifies municipal and industrial waste treatment plants with respect to adequacy of capacity and operation. Twenty-eight of the 70 industrial waste treatment plants are listed as inadequate in Table E, and the adequacy of 9 has not been determined. Of the 187 industrial plants with separate waste outlets, 33 have known adequate waste treatment facilities. In general, treatment plants have been rated as having satisfactory capacity if their capacity is equal to, or greater than, that required to handle present loads during critical periods. However, some of the plants which are now adequate, but which will be inadequate for loads which are now forseeable, have been included in subsequent tables as requiring treatment plant projects. For this and other reasons, the data in Tables C, D, and E do not necessarily agree with project requirements as shown in Tables G, H, and I. In some cases, even though adequate waste treatment facilities are not provided, the present or forseeable waste load is so small that no project is required at the present time. In other cases, project requirements may be undetermined pending the establishment of stream quality standards.

The plants for which the operation has been reported as excellent, good, or fair during critical periods have been classified in Table E as being satisfactory with respect to operation. The importance of good operation may be somewhat overlooked in view of the emphasis placed on obtaining installation of adequate treatment facilities. Good effluent results may frequently be obtained by correct operation of inadequate plants, and conversely,

poor operation of even the best of treatment plants will result in an unsatisfactory effluent. Good treatment plant operation is of great importance in an effective pollution abatement program.

Table F shows the number of municipal and industrial waste treatment facilities which have been installed each year from 1946 to 1949, inclusive. The total number of projects completed when compared to the number of projects required at the present time may indicate that little progress has been made in the abatement of pollution. However, it should be pointed out that the construction of pollution abatement works was at a standstill during World War II, and following the war industrial conversion to peace time production, together with unstable labor and materials markets, further impeded construction. Nevertheless, during this period State water pollution control agencies did make real progress by recreating the public awareness of the necessity for pollution control, by assisting municipalities and industries in planning for corrective action, by the development of effective legislation, and by the issuance of abatement orders against those offenders unwilling to initiate reasonable steps for corrective action. As a result of these activities, many pollution abatement projects are now in the planning and construction stages with the full support of the public and industrial management. The Lake Erie pollution survey now being conducted by the State of Ohio, discussed in more detail under the Lake Erie Shore Line Sub-Basin, will also provide essential data to properly evaluate the pollution problem along the Ohio section of the Lake Erie shore line.

Analysis of State Water Pollution Control Legislation[4]

The following analysis presents briefly the salient features of water pollution control legislation of the various States in the Lake Erie Drainage Basin. It is based on previous analyses of State legislation which were reviewed by the various States and used in the development of a Suggested State Water Pollution Control Act, which was subsequently endorsed by the Council of State Governments and recommended to the States for favorable consideration. The legislation of the States of Indiana, Michigan, Ohio and Pennsylvania are considered in this analysis. While a very small area in New York drains to Lake Erie through Pennsylvania, it has no significance with respect to stream pollution.

[4]Comprehensive water pollution control legislation was enacted by the Ohio legislature in June 1951.

Three of the four States in the Lake Erie Drainage Basin--Indiana, Michigan and Pennsylvania--have established boards or commissions which have comprehensive water pollution abatement, prevention, and control powers and duties. Ohio has vested the State Department of Health with water pollution control prevention and abatement functions.

Indiana, Michigan and Pennsylvania have established special boards or commissions of the mixed type. In Indiana and Michigan the boards or commissions are composed of ex officio members representing State government and members representing affected interests. In Pennsylvania the board is composed of designated ex officio members and three members appointed by the Governor with the approval of the Senate.

Indiana is the only State in the basin which specifically provides by statute for an executive officer or technical secretary to be in charge of the water pollution control program.

None of the water pollution control authorities in the basin are specifically required by statute to develop comprehensive programs for the prevention, abatement and control of water pollution or to classify waters according to use. However, some of the States have interpreted the pollution control acts to permit and, particularly in Pennsylvania, to possibly require development of such programs in carrying out the provisions of the acts. The Indiana, Michigan, and Pennsylvania water pollution control authorities are empowered to set standards of water quality.

All the States in the basin by statute require a permit after review of plans and specifications for the construction of new sewage and treatment works and extensions thereof. In Michigan, however, although the Water Resources Commission has general control of pollution of all waters of the State, the Department of Health is given the duty of issuing such permits.

All the States in the basin are authorized to issue general rules and regulations relating to water pollution control. In Indiana and Pennsylvania a hearing is required prior to such issuance.

Administrative orders relating to pollution abatement and control may be issued after hearing by all State water pollution control agencies in the basin. In Michigan, the Department of Health also is empowered to issue orders relating to sewerage and sewage treatment; no hearing is required prior to the issuance of such orders.

The water pollution control authorities in all States in the basin are given the statutory authority to hold administrative hearings in connection with the carrying out of their functions. Indiana and Pennsylvania are given

Table C.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	29	26	881,276
Secondary	70	51	1,534,126
No treatment	107[1]	--	389,047

*Includes incorporated or unincorporated municipalities; other legal bodies such as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

[1]Includes data for 40 communities having no comprehensive public sewerage systems, but for which population data are available. These communities have an estimated combined population of 33,280.

the specific statutory power to issue subpoenas and administer oaths in connection with such hearings.

In Pennsylvania, acid mine drainage from coal mines is exempt from the operation of the State Water pollution control statutes until the Sanitary Water Board determines that the polluting properties of such drainage are known.

Table D. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products..	84	28	55	1
Textile mill products.....	2	0	2	0
Paper and allied products.....	9	3	6	0
Chemical and allied products.....	19	6	10	3
Products of petroleum and coal.....	16	11	5	0
Rubber products.....	9	1	2	6
Leather and leather products.....	2	1	1	0
Primary metal industries...	15	8	7	0
Fabricated metal products..	20	9	11	0
Miscellaneous.....	11	3	8	0
Totals.....	187	70	107	10

*Industries having separate outlets and discharging wastes directly to watercourse

Table E. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	77*	43**	32***	2	65	8	4
Industrial	70	33	28	9	51	8	11

* 77 treatment plants serving 99 municipalities.
** 43 treatment plants serving 48 municipalities.
*** 32 treatment plants serving 49 municipalities.

Table F. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	3	Undetermined
1947	1	5,500	4	Undetermined
1948	2	8,000	4	Undetermined
1949	2	26,500	6	Undetermined

POLLUTION PREVENTION MEASURES REQUIRED

Table G lists the municipal and industrial waste treatment requirements in the basin as reported by the State water pollution control agencies. There are 206 locations, classed as municipalities, which are listed as contributing pollution to the streams. This classification includes incorporated or unincorporated municipalities, other legal bodies such as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers. Of these, 61, or 30 percent of the total number, are listed under "No project required" for pollution abatement. Approximately 35 percent of the population contributing to the pollution load from the municipal sources is located in these 61 municipalities. Tentative requirements at other municipalities include: new plants to serve 91 municipalities, enlargements of or additions to existing plants serving 41 municipalities, and replacements of existing plants serving 10 municipalities. These represent 44, 20, and 5 percent, respectively, of the total number of municipal sources of pollution; and 14, 49, and 2 percent, respectively, of the total sewered population of all the sources. The requirements of 3 municipalities have not been determined. On a population basis, these 3 municipalities represent less than one percent of the total population listed as contributing pollution to the streams. The 142 locations listed as requiring new or improved waste treatment facilities fall within the following population groups, using 1940 census data as a basis for classification: 49 with populations greater than 2,500, of which one exceeds 400,000, two exceed 300,000 and another exceeds 250,000; 43 with populations from 1,001 to 2,500; 38 with populations from 501 to 1,000; and 12 with populations of 500 or less.

Of the 187 sources of industrial pollution listed, 35, or 19 percent, are classified as requiring no project for pollution abatement. Some of these sources do not now have treatment. They are included as sources of pollution, but apparently do not contribute pollution significant enough to require waste treatment plants at the present time. Tentative industrial waste treatment requirements include 96 new plants, 22 enlargements or additions to existing plants, and 11 replacements of existing plants. These represent 51, 12, and 6 percent, respectively, of the total number of industrial sources of pollution. The requirements at 23 locations, or 12 percent, are undetermined. The pollution problems at many of these 23 locations are of minor significance.

The construction program required to obtain satisfactory treatment of industrial and municipal wastes will not require the number of separate treatment plants indicated by Table G. Some small municipalities which now require projects may connect to large adjoining municipal systems which provide treatment. Some industrial plants may control their wastes by changes in plant processes, while others may connect to municipal sewage treatment plants. Others have been listed by the State water pollution control agencies for long range planning purposes and may contribute little to the pollution picture at the present time.

Table H indicates status of treatment works projects to abate pollution for all sources now requiring projects. The first six steps indicated in the table are listed in order of progress of projects and each project is listed only in its most advanced stage. This method of listing does not indicate the total number of abatement orders issued by State water pollution control agencies. Also the table does not fully indicate the pollution control accomplishments of the State water pollution control agencies. Much progress has been made both with municipalities and industries, through cooperative action such as field contacts and consultation service which has resulted in corrective action without the necessity of formal orders.

Of the 142 sources of municipal pollution listed as requiring waste treatment projects and 3 sources listed under undetermined project requirements, there has been no formal action taken to abate pollution at 77, definite corrective action has been initiated at 60, and the status of 8 has not been determined.

Of the 129 industrial sources of pollution listed as requiring waste treatment projects and 23 sources listed under undetermined project requirements, there has been no formal action taken to abate pollution at 124 sources, definite corrective action has been initiated at 17, and the status of 11 has not been determined.

The needs for water pollution abatement should receive full consideration in any comprehensive water resources development which may be proposed in the basin.

A major requirement of an effective water pollution control program is adequate State

legislation to promote pollution abatement. The State water pollution control program in Ohio would be materially strengthened by enactment of a comprehensive water pollution control act similar to that approved by the Council of State Governments.[5] There is also need for fuller recognition of appropriation requirements of State water pollution control agencies to permit adequate enforcement of abatement requirements, supervision of treatment operation, and field work necessary to determine pollution conditions and establish abatement objectives.

Despite the fact that the cost per capita for sewage treatment is, or would be, one of the smallest of the average family's expenditures, the cost of sewage treatment plants and interceptor sewers is still of major concern in promoting effective pollution abatement. Also, the cost of industrial waste treatment is important in competitive enterprises.

An accurate estimate of the cost for needed waste treatment projects in the basin would require numerous data which are not now available. The degree of required treatment is an important cost factor. Costly interceptor sewers at some locations may cause wide variation from average costs. The cost of treatment of wastes from some industrial processes will be dependent on results of needed waste treatment research. With these serious limitations on accuracy, the estimate of cost for pollution abatement will reflect only the general magnitude of the cost of the program.

Based on a limited amount of data from recent estimates of cost for sewage treatment plants for which final plans have been prepared, and on adjusted pre-war cost curves, the capital cost of required municipal treatment projects, including allowance for interceptor sewers, is estimated to be between $35,000,000 and $40,000,000. The capital cost for providing required facilities to treat organic industrial wastes which are discharged directly to the watercourse (i.e. not connected to municipal systems) is estimated to be between $10,000,000 and $20,000,000. This estimate is subject to wide variation, depending on the extent to which it will be found feasible to collect and treat industrial wastes in municipal systems. Additional capital expenditures are required for facilities to treat inorganic wastes. The magnitude of the capital expenditures required for pollution abatement in the basin is in the range of $50,000,000 to $70,000,000. This estimate of costs covers only required municipal and industrial waste treatment plants and interceptor sewers and does not include the cost of installation of sewage collection systems in areas where comprehensive public sewer systems do not exist.

Recognizing that these expenditures will take place over a number of years, the estimated costs will be increased due to added factors. These include additional annual obsolescence and rehabilitation requirements, needs of communities installing new sewer systems, normal population increases and industrial expansion, as well as allowance for presently undetermined needs.

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[5] Comprehensive water pollution control legislation was enacted by the Ohio legislature in June 1951.

Table G. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number**	Population served by facilities	Number**
New plant	91***	379,810***	96
Enlargement or additions to existing plant	41****	1,388,051	22
Replace existing plant	10	48,163	11
No project required	61[1]	982,155[1]	35
Undetermined	3[2]	6,270[2]	23

*The needs as set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these requirements

**The numerical values representing requirements are based on the number of municipal and industrial sources of pollution. These values may differ considerably from the actual number of projects required because of the possibility of multiple sources of pollution being or becoming tributary to one treatment plant, or because of multiple treatment plants existing or being required at one location. See footnotes under sub-basin Tables G.

***Includes data for 26 communities having no comprehensive public sewerage systems. These communities have an estimated combined population of 27,518.

****19 of these locations are served by 3 treatment plants: A part of Cleveland and all or part of 13 other small communities are served by one plant; three other communities are served by one plant; Akron and one other community are served by one plant.

[1]Includes data for 13 communities having no comprehensive public sewerage systems. These communities have an estimated combined population of 5,192.

[2]Includes data for 1 community having no comprehensive public sewerage system. This community has an estimated population of 570.

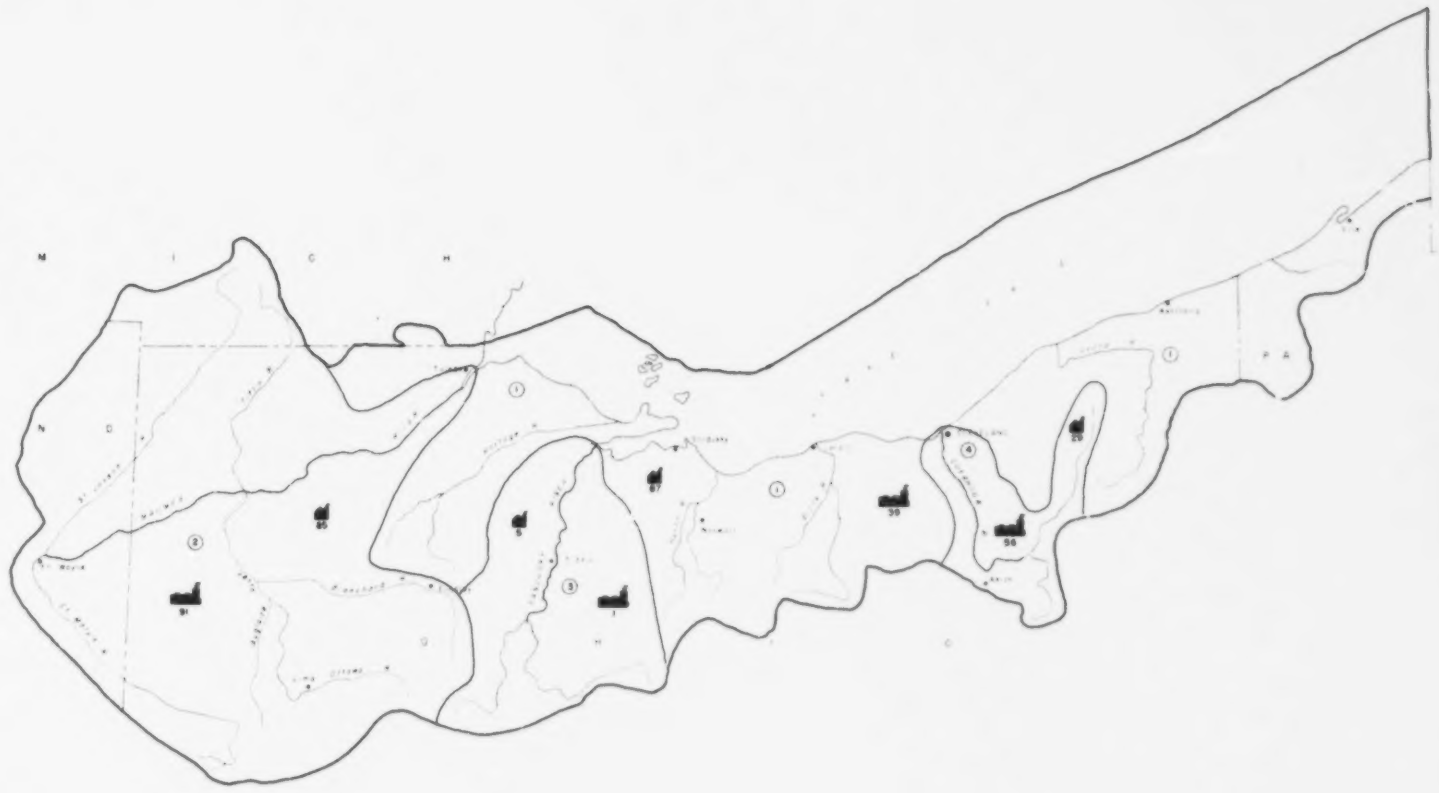
Note: For a listing of individual project needs refer to Tables I included in the sub-basin discussions which follow the main part of this report.

Table H. Status of treatment works projects to abate pollution, July 1, 1950

Status of project*	Number	
	Municipal	Industrial
No formal action**	77	124
Abatement ordered	1	2
Plans under preparation	21	11
Final plans approved	36	4
Construction awaiting financing	0	0
Under construction	2	0
Status undetermined	8	11

*Projects required for pollution abatement may have proceeded through several of the stages indicated but are listed only once at the most advanced stage.

**Means that State control agencies have not issued abatement orders or that municipalities or industries have not reached the engineering planning stages for corrective works.



14-B

SUB – BASIN INDEX

① Lake Erie Basin
② Maumee River Basin
③ Sandusky River Basin
④ Cuyahoga River Basin

NUMBER OF MUNICIPAL SOURCES

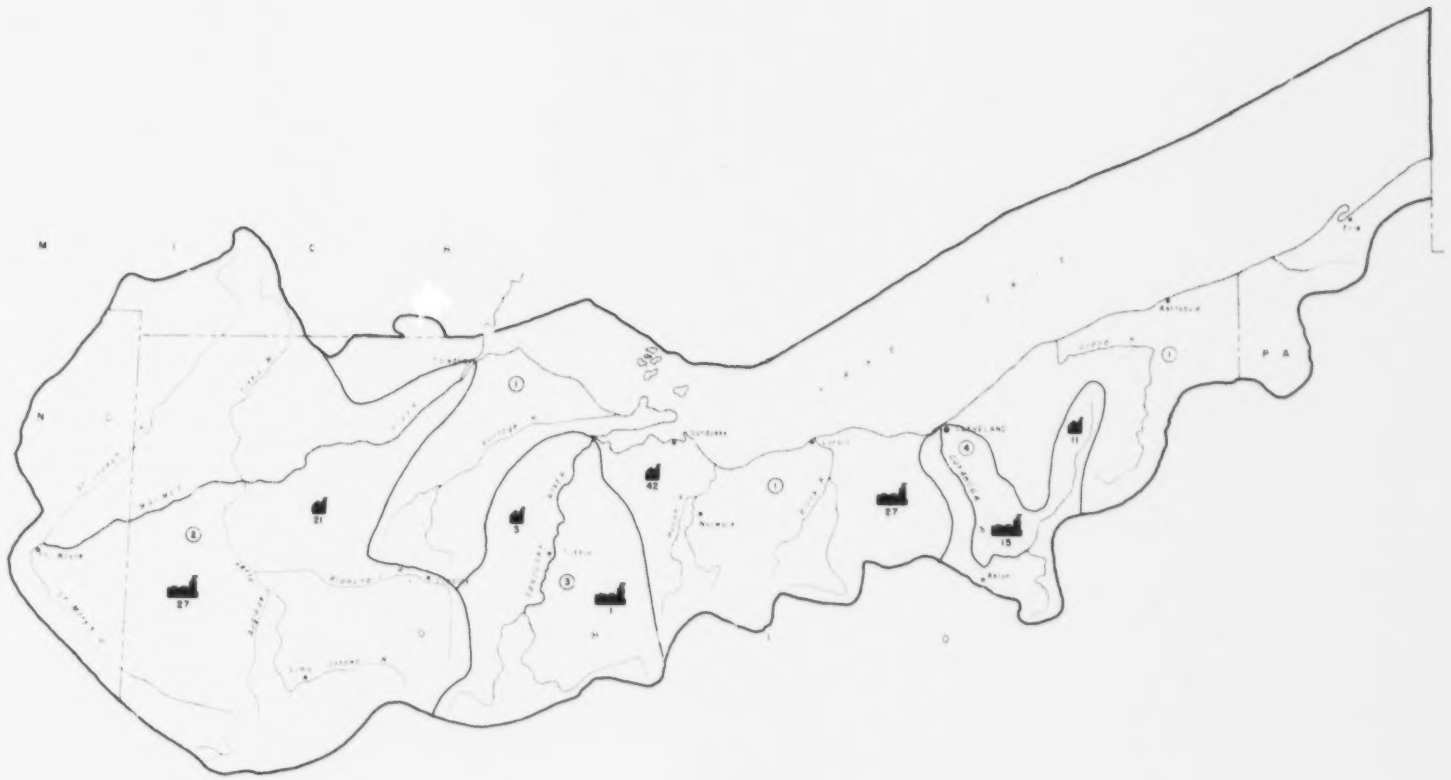
NUMBER OF INDUSTRIAL SOURCES

SCALE OF MILES
10 0 10 20 30

LAKE ERIE DRAINAGE BASIN
SOURCES OF POLLUTION

FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL

MAP NO. 1



SUB — BASIN INDEX

① Lake Erie Basin
② Maumee River Basin
③ Sandusky River Basin
④ Cuyahoga River Basin

▪ NUMBER OF EXISTING MUNICIPAL TREATMENT WORKS

▪ NUMBER OF EXISTING INDUSTRIAL TREATMENT WORKS

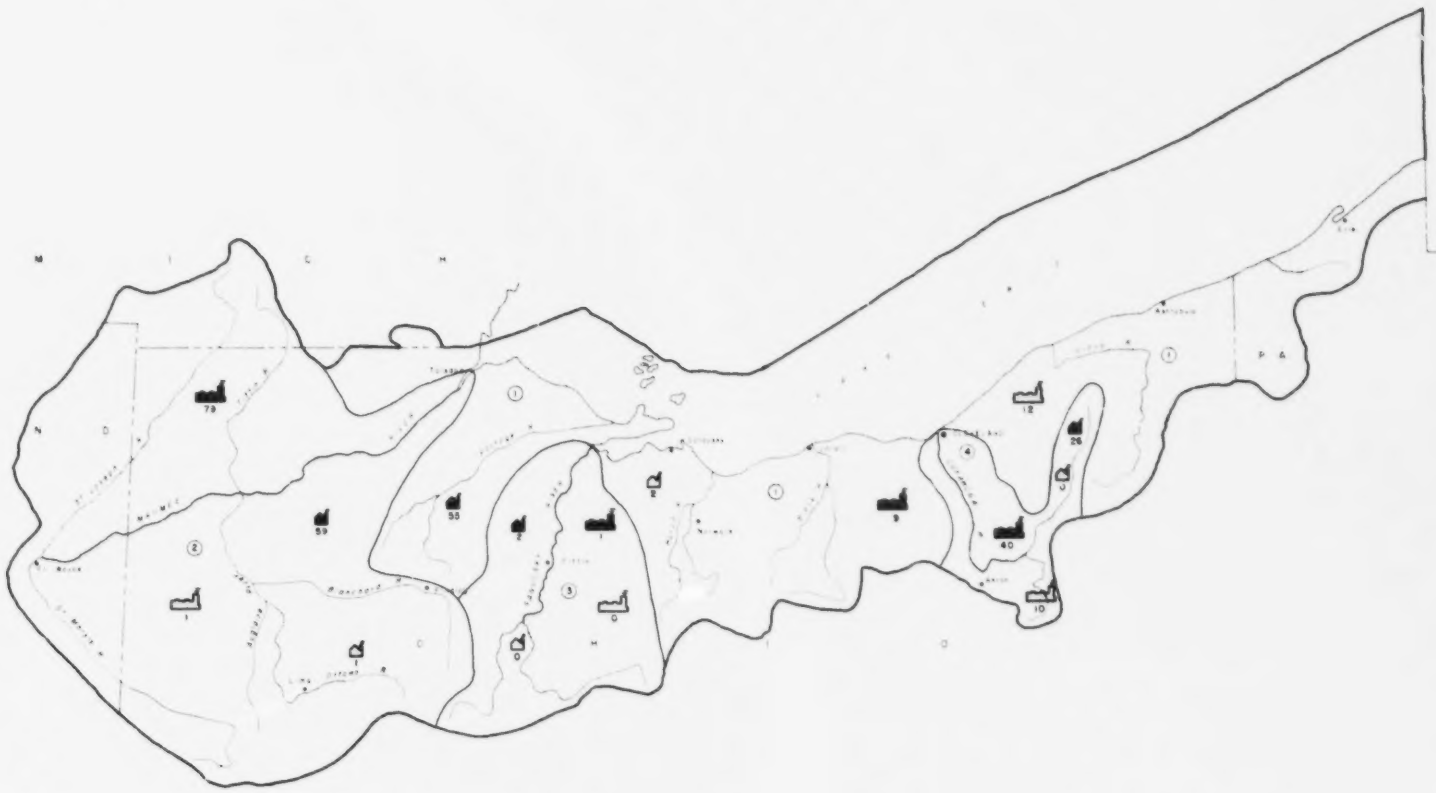
SCALE OF MILES
10 0 10 20 30

LAKE ERIE DRAINAGE BASIN

EXISTING TREATMENT WORKS

FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL

MAP NO. 2



M-C

SUB-BASIN INDEX

① Lake Erie Basin
② Maumee River Basin
③ Sandusky River Basin
④ Cuyahoga River Basin

NUMBER OF MUNICIPAL PROJECTS REQUIRED

NUMBER OF MUNICIPALITIES WITH PROJECT REQUIREMENTS UNDETERMINED

NUMBER OF INDUSTRIAL PROJECTS REQUIRED

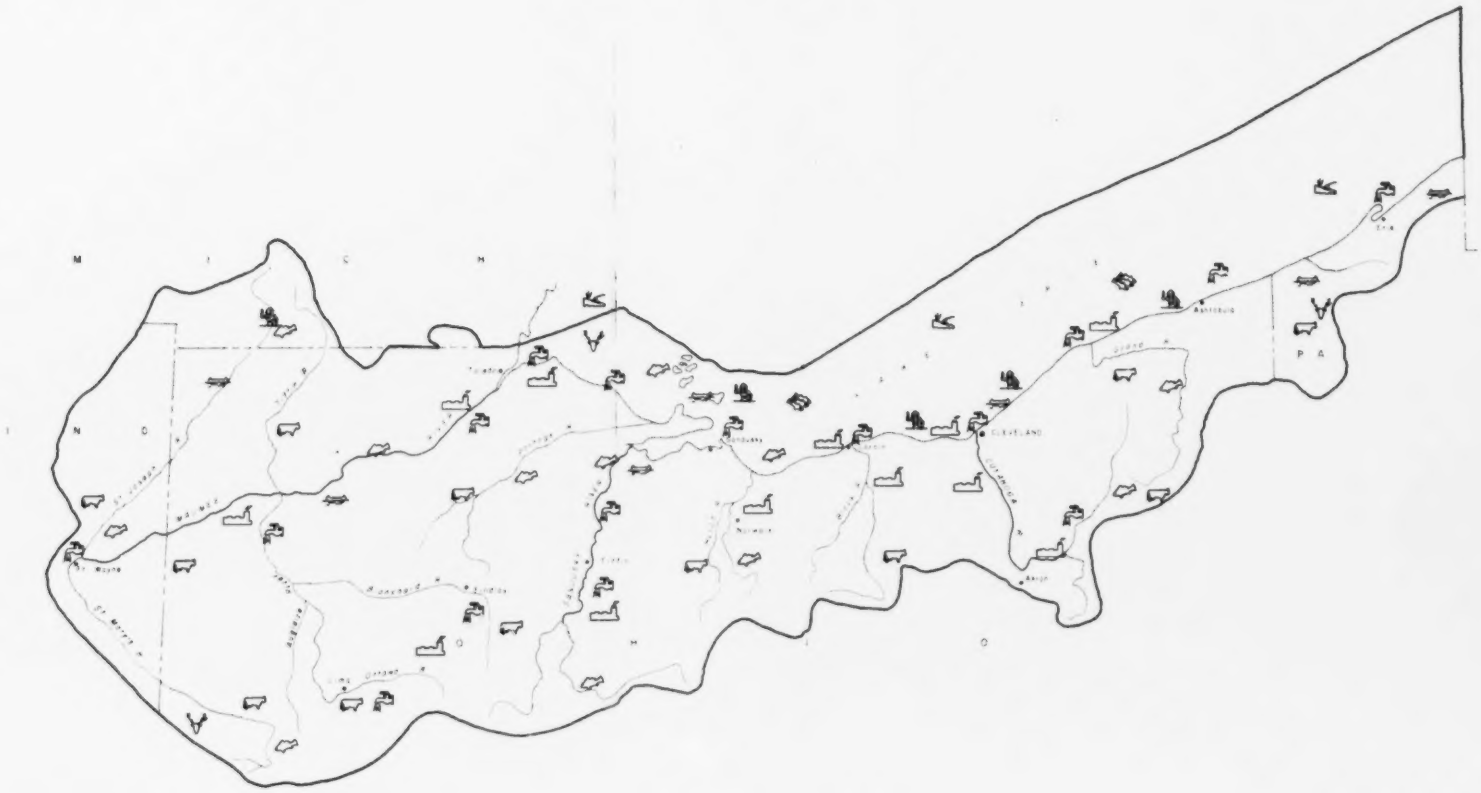
NUMBER OF INDUSTRIES WITH PROJECT REQUIREMENTS UNDETERMINED

SCALE OF MILES
10 0 10 20 30

LAKE ERIE DRAINAGE BASIN
PROJECTS REQUIRED

FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL

MAP NO 3



DOMESTIC WATER SUPPLY
INDUSTRIAL WATER SUPPLY
LIVESTOCK
COMMERCIAL FISHING
GAME FISHING
WILD LIFE
BATHING WATER
OTHER RECREATION
NAVIGATION

SCALE OF MILES
10 0 10 20 30

LAKE ERIE DRAINAGE BASIN

EXISTING PRIMARY WATER USES

FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL

MAP NO 4

14-D

SUB-BASIN REPORTS

LAKE ERIE SHORE LINE AND MINOR TRIBUTARIES SUB-BASIN

General Description

The Lake Erie Shore Line and Minor Tributaries Sub-Basin, as considered in this report, includes those portions of the Lake Erie watershed in Michigan, Ohio, Pennsylvania, and New York which drain into Lake Erie in that stretch of the southern lake shore between the Michigan-Ohio State line on the west and the Pennsylvania-New York State line on the east, exclusive of the Maumee River, Sandusky River, and Cuyahoga River watersheds. These three drainage areas are treated elsewhere in this report as separate sub-basins.

The Lake Erie Shore Line Sub-Basin has an area of approximately 5,175 square miles, most of which is in Ohio. An area of about 515 square miles in the extreme northwest corner of Pennsylvania is included in this sub-basin. A small area of about 50 square miles in Michigan is drained by the Ottawa River (Ten Mile Creek), which flows through Ohio for a short distance before it discharges to Maumee Bay at the western end of Lake Erie. Another small area of about 38 square miles in western New York is drained by Twenty Mile Creek, which flows through a small corner of Pennsylvania on its way to Lake Erie. No pollution has been reported from either of these small areas in Michigan and New York. The shore line areas of Michigan and New York that drain directly into Lake Erie are not included in this report.

Economic Development

Since the Civil War there has been a rapid increase in population in the sub-basin. Many cities along the southern shore of the lake owe their rapid growth to their favored positions on that waterway. From the start they have been transshipping centers, where coal is transferred from trains to ships which take the black cargo up to the cities of Chicago, Ill.; Milwaukee, Wis.; Marquette, Mich.; Duluth, Minn., and others. In the reverse direction, the ships bring vast tonnages of ore and grain to the Lake Erie ports.

Fishing is an important industry in the lake, although not as profitable as in the past. Sandusky, Ohio, is the leading fishing port on the lake, but other ports, especially near the east and west ends of the lake, boast considerable fishing industries.

Agriculture is widely practiced in the rural areas along the southern shore and in the islands of the western portion of the lake. The area is well known for its vineyards and orchards. Grape juice and wines are important products of the Lake Erie shore region.

A wide variety of manufacturing industries exist in the sub-basin, the most important of which include those producing primary metals, fabricated metal products, machinery, textiles, wearing apparel, and food products.

Recreational developments, both public and private, are economically important in the area. Tourist cabins and fishing boats are available for rent along the entire shore line and on the islands. Beach resorts and bathing areas are also found throughout the shore line. Other vacation attractions, not directly related to water sports, have been developed. Regular air service and boat service is maintained between points on the mainland and the islands. Well equipped State parks are available for use of vacationers. Tours are conducted daily for sightseeing and fishing throughout the vacation season.

Rainfall and Runoff

The average annual rainfall of the Lake Erie shore line drainage area is about 34 inches. The U. S. Weather Bureau has maintained 17 rainfall gaging stations scattered throughout the sub-basin. The mean annual rainfall varies from station to station, with generally higher values toward the east. Catawba Isalnd, in Ottawa County, Ohio, has the lowest recorded rainfall with a mean annual rate of 28.19 inches for a 23-year period. A 22-year period at Hillhouse in Lake County, Ohio, shows a mean annual rate of 39.57 inches. The precipitation is distributed fairly uniformly throughout the year.

Stream flow data have been collected and recorded in publications of the States and of the U. S. Geological Survey. A regrettable lapse of records occurred from 1936 to 1939, and it was during that period that the unprecedented flood flows of January, 1937, and the drought of 1936 took place. These extreme flows, if known, would greatly increase the value of the records. However, a considerable amount of flow data are available, and the flow gaging program is being expanded.

The flow records for the Portage River at Woodville, Ohio, show an average discharge of

261 second-feet for a 15-year total period of record. This amounts to a runoff of about 0.6 cubic foot per second per square mile from the 433 square miles of drainage area above Woodville. The minimum recorded flow, 0.3 second-foot, occurred on August 28, 1931.

The Grand River at Madison, Ohio, has a higher rate of runoff. A total record of 22 years shows an average runoff of 634 second-feet from the watershed of 587 square miles above that station. This amounts to a runoff of 1.08 second-feet per square mile.

Major Shore Line or River Developments

Numerous harbors exist along the shore line, many of which have been improved to accommodate large vessels. Inner harbor channels and entrances have been dredged and piers, revetments, and breakwaters have been constructed for the convenience and protection of shipping. Harbor improvements have been accomplished by Federal, State, and local governments, and by private organizations.

Numerous recreational facilities have been developed along the shore line of Lake Erie. Beaches and parks, both private and public, help satisfy the great recreational demands of the population. At the request of the Corps of Engineers, the U. S. Public Health Service has made pollution surveys of some of the beaches. The information from these surveys is used in analyzing beach and shore line maintenance requirements.

Population

The 1940 population of the Lake Erie Shore Line Sub-Basin was approximately 1,787,000. This figure excludes Toledo, Ohio, for though that city lies partly within this sub-basin, it discharges all of its sewage into the Maumee River. All of Cleveland's population is included in the Lake Erie Shore Line Sub-Basin population figure, although part of Cleveland, Ohio, is sewered to the Cuyahoga River.

Those communities now recognized as significant sources of pollution accounted for about 1,482,000 of the 1940 population.

Water Uses

Surface waters are widely used in the Lake Erie Sub-Basin as domestic and industrial water supply sources. There are 26 separate water supply systems in Ohio with intakes extending out into Lake Erie. Two of these take Lake Erie water to serve Cleveland and 52 nearby communities. A third plant in Cleveland, not yet completed, will also use the lake as its source. Toledo and Maumee, Ohio, discharge their wastes to the Maumee River and, for purposes of this report, are considered to be wholly within the Maumee River Sub-Basin. However, they are served by a water treatment plant which has its intake in Maumee Bay of the shore line sub-basin.

Six of the 26 Lake Erie water intakes serve industries, while the remaining 20 supply domestic and industrial water to 99 municipalities or other population centers. Surface streams on Ohio tributary to Lake Erie are used as sources of water by 12 treatment plants serving 14 communities.

In the Pennsylvania shore line area, Lake Erie water is treated by two plants for use in Erie City and three adjacent communities. One Pennsylvania town in the sub-basin is supplied partly from a small stream tributary to the lake.

In all, there are 35 municipal water treatment plants using surface waters in the sub-basin. These plants serve 118 communities with a combined population of about 1,880,000. An estimated population of 1,825,200 is served by plants taking water from Lake Erie and a population of 54,800 is served by plants taking water from other surface sources. In addition, there are other locations throughout the shore line area where surface water is used on a smaller scale for domestic and industrial purposes.

In the rural areas, surface streams are widely used for stock watering and recreation. As previously mentioned, recreational developments in the area are extensive and recreation is one of the most important uses of the surface waters in the sub-basin.

Economically, navigation is the most important use made of Lake Erie. The shipping lanes between Buffalo and Detroit are among the busiest in the world.

Sources of Pollution

There are 87 municipalities discharging wastes to the surface waters of the Lake Erie Shore Line Sub-Basin. The sewerage systems of these cities and other population centers serve a combined population of about 1,358,200. In addition, a considerable industrial waste load of unknown population equivalent is discharged by industries into these public sewers. After treatment varying from none to secondary treatment in the various towns, a known waste load of some 726,700 population equivalent is discharged to the streams. In addition, a load of unknown population equivalent enters the streams from some of the municipalities at which no accurate biochemical oxygen demand measurements have been obtained.

There are 39 industries in the sub-basin which discharge wastes to the streams through private sewers. Of these, 21 produce organic wastes, 4 produce inorganic wastes, 6 produce combined organic and inorganic wastes, and 8 discharge wastes of undetermined type.

There are additional small sources of pollution scattered throughout the sub-basin, but because of their size and location, they are of minor significance.

Silt from agricultural lands constitutes a significant source of pollution. Data on the extent and damaging effects of this pollution have not been fully obtained for this report.

Effects of Pollution on Water Uses

Pollution discharged to the streams has had a deleterious effect on some of the legitimate water uses. Livestock water supplies have been reduced in quality by wastes in some of the sub-basin streams. This damage has occurred principally in tributaries of the Portage, Huron, Black, Rocky, and Chagrin Rivers. Industrial water supplies have been affected on the Black River. Game fishing and other forms or recreation have been curtailed in tributaries of the Rocky and Chagrin Rivers.

One of the most serious pollution problems in the sub-basin is the adverse effects of pollution on bathing water quality. A survey by the City of Cleveland in 1949[6] shows that pollution of the water at the bathing beaches in the Cleveland area was greater in 1949 than in 1939-1941. Also, based on the coliform index, the degree of pollution was several times worse than any standard which has been proposed for safe bathing water. Overflows incident to the interception of sewage from the combined sewer system of the area represented a major cause of shore water pollution.

The problem became so serious that the Ohio State Legislature appropriated $100,000 in 1949 to be used during the biennium to conduct a pollution survey of Lake Erie. Although the appropriations were made to the Department of Natural Resources, the Department of Health and Franz Theodore Stone Laboratory are cooperating and assisting the Division of Water of the Natural Resources Department in conducting the survey. The Division of Water is responsible for collecting data on stream flows and the chemical and physical (silt) qualities of the waters in Lake Erie and those entering the lake from Ohio. The Stone Laboratory is responsible for biological investigations of stream and lake waters and a study of lake currents. The Division of Sanitary Engineering of the Department of Health is responsible for the sanitary analyses of stream and lake waters. The sanitary study is particularly concerned with the quality of bathing beach waters and surface water supply sources along the entire shore line. Several of the lake shore cities, through their water and sewer departments, are assisting in the collection of data. As a result of this study considerable data necessary to develop a reasonable water pollution control and water use program is being made available to the local and State authorities. Another important phase of this study is the measurement of the silt load entering the lake and the possible effects of silt and pollution on the biological life of the lake and tributary streams.

Fluctuations in fish populations have been of major concern to commercial fishing interests for many years. These fluctuations are somewhat cyclical in nature but show a tendency toward decline of the more desirable species. The cause and remedy for these fluctuations have been the subject of much investigation and research. While there is not universal agreement on the principal causes, there is strong evidence pointing to siltation and pollution of spawning areas as major factors.

Treatment Provided

Primary sewage treatment is provided by 16 plants serving 17 communities with a population served of some 522,900. Twenty-six secondary plants treat sewage from a connected population of about 664,400 in 31 population centers. In addition to the domestic wastes, an undetermined amount of industrial waste is handled by municipal sewage treatment works.

Of the 39 industries discharging wastes directly to streams through private sewers, 27 have provided some form of treatment.

Treatment Plants Required

Table G_1 indicates the present estimate of treatment plant requirements in the Lake Erie Shore Line Sub-Basin. A total of 37 new plants, 12 enlargements or additions, and 6 plant replacements are needed at municipal sources of pollution. Thirty municipalities are considered to have satisfactory waste disposal facilities and for these locations no projects are required. Requirements at two towns are undetermined.

At industrial sources of pollution, 3 new treatment plants, 3 enlargements of or additions to existing facilities, and 3 plant replacements are needed. The waste treatment requirements at 12 industrial sources have not yet been determined.

Tabular Data

Tables A_1 through I_1 present additional data relative to pollution in the sub-basin.

[6] "Sewage and Industrial Wastes", December 1950, page 1618.

Table A_1. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	80[1]	1,327,615[1]	726,681[1]
Having population data available (Data on pollution load to watercourse incomplete or not available)	7[2]	30,625[2]	Not applicable
Total	87	1,358,240	--

*Includes incorporated or unincorporated municipalities; other legal bodies such as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

**Includes estimates of industrial wastes discharged into municipal sewerage systems. In some instances the estimates are incomplete.

[1]Includes data for 9 communities having no comprehensive public sewerage systems. These 9 communities have an estimated combined population of 13,614.

[2]Includes data for one community having no comprehensive sewerage system. This community has an estimated population of 564.

Table B_1. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	10**	330,712
Producing organic wastes	17[1]	Undetermined
Producing inorganic wastes	10	Not applicable
Producing wastes of undetermined type	8	Undetermined
Total	39[2]	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Includes 5 plants also producing inorganic wastes

[1]Includes 1 plant also producing inorganic wastes.

[2]Total adjusted to correct for duplication noted in footnotes marked thus: ** and [1].

Table C_1.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	17	16	522,914
Secondary	31	26	664,432
No treatment	39**	--	170,894**

*Includes incorporated or unincorporated municipalities; other legal bodies such as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

**Includes data for 10 communities having no comprehensive public sewerage system, but for which population data are available. These communities have an estimated combined population of 14,178.

Table D_1. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products..	17	11	5	1
Paper and allied products..	5	3	2	0
Chemical and allied products.....	5	2	--	3
Products of petroleum and coal.....	1	1	0	0
Leather and leather products.....	1	1	0	0
Primary metal industries...	2	2	0	0
Fabricated metal products..	6	5	1	0
Miscellaneous.....	2	2	0	0
Totals.....	39	27	8	4

*Industries having separate outlets and discharging wastes directly to watercourse.

Table E_1. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	42*	24**	17***	1	36	5	1
Industrial	27	18	6	3	22	1	4

* 42 treatment plants serving 48 municipalities.
** 24 treatment plants serving 29 municipalities.
*** 17 treatment plants serving 18 municipalities.

Table F_1. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	0	--
1947	1	5,500	2	Undetermined
1948	1	2,000	1	Inorganic
1949	1	6,500	3	Undetermined

Table G_1. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number**	Population served by facilities	Number**
New plant	37[1]	169,359[1]	3
Enlargement or additions to existing plant	12	362,929	3
Replace existing plant	6	29,312	3
No project required	30[2]	791,770[2]	18
Undetermined	2[3]	4,870[3]	12

*The needs as set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these requirements.

**The numerical values representing requirements are based on the number of municipal and industrial sources of pollution. These values may differ considerably from the actual number of projects required because of the possibility of multiple sources of pollution being or becoming tributary to one treatment plant, or because of multiple treatment plants existing or being required at one location.

[1]Includes data for 8 communities having no comprehensive public sewerage systems. These communities have an estimated combined population of 12,643.

[2]Includes data for 1 community having no comprehensive public sewerage system. This community has an estimated population of 965 for which treatment is provided.

[3]Includes data for 1 community having no comprehensive public sewerage system. This community has an estimated population of 570 for which no treatment is provided.

Table H_1. Status of treatment works projects to abate pollution, July 1, 1950

Status of project*	Number	
	Municipal	Industrial
No formal action**	36	11
Abatement ordered	0	0
Plans under preparation	9	5
Final plans approved	8	2
Construction awaiting financing	0	0
Under construction	0	0
Status undetermined	4	3

*Projects required for pollution abatement may have proceeded through several of the stages indicated but are listed only once at the most advanced stage.

**Means that State control agencies have not issued abatement orders or that municipalities or industries have not reached the engineering planning stages for corrective works.

Table I_1. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served**	Project requirements	Remarks
OHIO			
Port Clinton	4,505	New plant	Final plans approved.
Put-in-Bay	202	New plant	--
Lakeside	754	New plant	(1)
Kelleys Island	564	New plant	(1)
Sandusky	24,874	New plant	--
Cedar Point	5,000	New plant	(1)
Vermilion	1,616	Enlargement	--
Lorain	44,125	New plant	Plans under preparation.
Sheffield Lake	1,099	New plant	--
Avon	2,118	New plant	(1)
Avon Lake	2,274	New plant	(1)
Rocky River	--	Enlargement	--
Lakewood	58,815	Enlargement	--
Cleveland Westerly Sewage Treatment Plant	417,000	Enlargement	Plans under preparation.
Parkview	--	Enlargement	Served by Cleveland Westerly Sewage Treatment Plant.
Wickliffe	3,155	New plant	--
Mentor	1,827	New plant	--
Mentor-on-the-lake	538	New plant	--
Fairport	4,528	New plant	--
Diamond Alkali	--	Undetermined	--
Ashtabula	21,405	New plant	Final plans approved.
Conneaut	9,355	New plant	Final plans approved.
Metamora	490	New plant	(1)
Sylvania	2,199	Replacement	--
Brush Beryllium Company	--	Undetermined	--
Genoa	1,455	New plant	Plans under preparation.
Woodville	1,219	New plant	--
Elmore	1,103	New plant	Plans under preparation.
Oak Harbor	1,925	New plant	Plans under preparation.
Pemberville	1,036	New plant	--
Pemberville Food Company	--	Replacement	--
Bloomdale	575	New plant	--
Seneca Wire & Steel Co.	--	Enlargement and additions	--
Fostoria	13,453	Replacement	Plans under preparation.
McComb	976	Additions	--
N. Baltimore	2,616	New plant	--
Cygnet	569	New plant	--
Bradner	890	New plant	--
Gibsonburg	2,169	New plant	Plans under preparation.
Gibsonburg Canning Co.	--	Replacement	--
Green Springs	930	Additions	--
Clyde	3,174	Replacement	Final plans approved.
Castalia	596	New plant	(1)
Bellevue	6,127	New plant	Final plans approved.
Soldiers and Sailors Home	1,500	Additions	--
Milan	719	Additions	--
Shiloh	519	New plant	--
Plymouth	1,403	New plant	Final plans approved.
Monroeville	1,173	New plant	--
Celotex Corporation	10,000	Replacement	Plans under preparation.
S. Amherst	847	New plant	(1)
National Tube Company, By-Product Coke Plant		Undetermined	

See footnotes at end of table.

Table I_1. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950--Continued

Name	Population served **	Project requirements	Remarks
OHIO --Continued			
National Tube Company, Blast Furnaces	--	Undetermined	--
National Tube Company, Steel Mills	--	Additions	--
Oberlin	6,305	Replacement	--
Lodi	1,304	Enlargement	--
Grafton	971	New plant	--
Medina	4,359	Enlargement	--
Olmsted Falls	754	New plant	--
Berea	6,025	Enlargement	Final plans approved.
Chase Bag Company	--	New plant	--
Chagrin Falls	2,505	Replacement	--
Willoughby	4,364	New plant	Final plans approved.
Painesville	12,235	New plant	Plans under preparation.
Jefferson	1,676	Replacement	--
Electro Metallurgical Division Union Carbide & Carbon Company	--	Undetermined	Plans under preparation.
Hooker Electro Chemical Company	--	Undetermined	Plans under preparation.
National Distillers Corp.	--	Undetermined	Manufacture metallic sodium; plans under preparation.
PENNSYLVANIA*			
Hammermill Paper Company	319,890	Additions[2]	([2])
Albro Packing Company	--	New plant	Plans under preparation.
Rieck McJunkin Dairy Co.	--	New plant	Final plans approved.
2 unnamed towns	--	Undetermined	([3])
5 unnamed industries	--	Undetermined	--

*The needs as set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these requirements.

**Amount of industrial organic waste is reported in terms of population equivalent as measured by B.O.D.

[1]No comprehensive public sewerage system.

[2]Final plans approved for additions to existing plant treating part of waste. Plans are needed for new plant to treat other wastes. Tabulated in table G_1 as requiring "Enlargement or additions to existing plant".

[3]Includes one town having no comprehensive public sewerage system.

MAUMEE RIVER SUB-BASIN

General Description

The Maumee River Sub-Basin comprises a fanshaped area of approximately 6,656 square miles, principally in northwestern Ohio, but including a portion of northeastern Indiana and a smaller portion of southeastern Michigan. The major tributaries to the Maumee River are the St. Joseph, St. Marys, Tiffin and Auglaize Rivers. The tributary of the Tiffin River which lies within Michigan is known as Bean Creek. The St. Joseph and St. Marys Rivers, which flow in southwesterly and northwesterly directions, respectively, join at Fort Wayne, Ind. to form the Maumee River. From this point the Maumee River flows about 110 miles in an east by northeasterly direction to Toledo, Ohio, where it discharges to Lake Erie. Both the Tiffin and Auglaize Rivers join the Maumee at Defiance, Ohio. The Tiffin River flows in a southerly direction and the Auglaize flows in a northerly direction.

The topography of the Maumee River Sub-Basin varies from flat and gently rolling plains throughout most of the Sub-Basin to moderately hilly areas in the headwater regions of the four main tributaries. The entire sub-basin is glaciated and much of its area was covered for a considerable period of time by glacial lake waters. Sedimentary deposits of clay and sand exhibit their influence on the soils of the region.

Economic Development

The primary occupation in the Maumee Sub-Basin is agriculture, but manufacturing is of considerable importance in the larger cities.

The greater portion of the land of the sub-basin is under cultivation. Diversified farming, dairying and some stock raising are practiced. Industrial activities in the sub-basin are also diversified. Manufactured products include locomotives, automobiles and trucks, machinery, electrical equipment, tools, food products and many others. Oil fields in the eastern portion of the sub-basin have passed their peak of productivity, but wells are still pumped periodically. Natural gas, produced in substantial quantities, in the area, is piped to metropolitan centers for domestic and commercial consumption. Lima, Ohio, is the center of an oil distribution system with pipelines extending from the oil fields of Wyoming, Texas and Oklahoma to the Great Lakes and eastern markets. Toledo, Ohio, is a railroad center and a very important coal shipping point.

Rainfall and Runoff

The average annual precipitation in the Maumee Sub-Basin is about 34.5 inches. This precipitation is distributed fairly evenly over the area. Average monthly precipitation varies from about 2 inches in February to about 3.8 inches in June.

Stream gaging records of the U. S. Geological Survey show that the average discharge of the Maumee River at Waterville, Ohio, for a period of record of 23 years (1921-35, 1939-48), was about 4,300 second-feet. The drainage area above this station is 6,314 square miles. The minimum recorded flow for the same period and at the same station was 32 second-feet and occurred in September 1941. The U. S. Geological Survey has maintained a number of other stream gaging stations on the Maumee River and its tributaries upstream from the station at Waterville. The 1948 Geological Survey Water-Supply Paper 1114 lists 21 stations in operation in the sub-basin during the water year 1947-48.

Major River Developments

The only existing major navigation improvement in the sub-basin is a Federal project which provides for a channel 25 feet deep from deep water in Lake Erie to a point 7 miles upstream from the mouth of the Maumee River. This channel serves as the connecting link between lake shipping and railroad facilities.

A privately owned hydroelectric power plant is located on the Auglaize River about 3 miles above its mouth. This plant has a rated generator capacity of 5,000 kilowatts and has been in operation since 1912. The city of Fort Wayne, Ind. has constructed one dam on the St. Joseph River to provide a reservoir for domestic water supply, and one dam on the Maumee River to provide a reservoir to supply power plant cooling water. Two small hydroelectric plants, with a combined capacity of 425 kilowatts are located in the sub-basin.

Considerable dike construction has been completed by the city of Fort Wayne. The dikes provide some measure of flood protection for the city. Dikes have also been constructed by local interests in the Bean Creek area for the control of spring freshets.

Population

The 1940 population of the Maumee River Sub-Basin was approximately 860,000. The combined 1940 population of all municipalities now listed as sources of pollution was approximately 624,600. These population figures include the entire population of Toledo, Ohio. This city is not entirely within the sub-basin, but its waste disposal facilities discharge to the Maumee River.

Water Uses

Water uses in the sub-basin include domestic, industrial, and livestock water supplies, navigation, and recreation. Ten municipal water supply systems in the sub-basin use surface streams as a source of all or part of their water. These supplies serve a total population of approximately 215,000 in ten municipalities. The city of Toledo uses Lake Erie as a source of domestic water supply and is not included in the above figures. The Toledo water system serves a population of about 300,000.

Sources of Pollution

The domestic wastes from a sewered population of about 647,000 in 85 communities are discharged to the streams of the sub-basin. The wastes from 60 of these communities, with a combined sewered population of about 630,000, discharge a waste load to the streams having a population equivalent of about 451,000. Population equivalent data for the wastes discharged from the remaining 25 communities, having a total population served of about 16,700, have not been obtained. However, these, in general, have little pollutional significance at this time.

Of the 91 industrial plants contributing wastes to the streams through private sewers, 13 produce both inorganic and organic wastes, 72 produce organic wastes only, and 6 produce inorganic wastes only. Of the 85 plants which produce organic wastes, 69 produce wastes which have a population equivalent of about 532,000. Population equivalent data for the wastes from the remaining plants have not been obtained.

Domestic and organic industrial wastes for which population equivalent data are available have a total combined population equivalent of about 983,000. Of this total known organic waste load discharged to all of the streams of the watershed, wastes with a combined population equivalent greater than 500,000 are discharged to the lower 2.5 miles of the Maumee River.

Effects of Pollution on Water Uses

Several public water supply sources are subject to the effects of pollution by wastes discharged at upstream locations. Although the water treatment plants are producing a water of satisfactory bacterial quality, the proximity of upstream pollution or bacterial pollution from sewage imposes potential health hazards which lower the quality of these raw waters below desirable sanitary standards as sources for domestic supply. Local nuisance conditions exist at some locations where wastes are discharged to small tributary streams. Pollution limits the use of many of the streams for industrial and livestock water supplies, for fishing and wildlife propagation, and for recreational activities.

Treatment Provided

Tables C_2, D_2 and E_2 present data concerning the status of waste treatment in the sub-basin. Of the 85 communities listed as sources of pollution in the sub-basin, 7 provide primary waste treatment (through 5 treatment plants), 16 provide secondary waste treatment, and 62 have no treatment facilities. On the basis of population served by sewer systems, however, these 62 sources represent less than 15 percent of the total, many of which have populations of less than 1,000. Thus over 85 percent of the sewered population in the sub-basin is tributary to sewage treatment plants. Nine of the existing plants, tributary population about 399,600, are reported to be overloaded however, and require plant enlargements, additions or replacement. Three of these plants, total tributary population approximately 375,000, either have construction plans approved or are now developing plans for corrective action.

Twenty-seven of the 91 industrial plants which discharge wastes to the watercourse provide some kind of waste treatment, the remaining 64 plants discharge their wastes untreated. Fifteen of the 27 industrial treatment plants which are now in operation in the sub-basin are considered inadequate by the State water pollution control agencies. Of the 69 industrial sources of pollution for which the population equivalent of the waste discharge is known, the 15 sources listed as having inadequate treatment discharge a population equivalent waste load of about 283,000, four listed as having satisfactory treatment discharge a population equivalent waste load of 21,500, two listed as having undetermined adequacy of treatment discharge a population equivalent waste load of about 27,500, and the

remaining 48, listed as having no treatment discharge a population equivalent waste load of about 200,000.

Treatment Plants Required

Table G_2 indicates present tentative estimates of waste treatment plant requirements in the sub-basin. Municipal requirements are: 48 requiring new plants, 2 requiring replacements, and 9 requiring enlargements or additions to existing plants. The requirements of one municipality have not been determined and 25 municipalities require no projects at this time. Industrial requirements are 61 new waste treatment plants, 4 replacement plants, and 14 enlargements or additions to existing treatment plants. Requirements are undetermined at one plant and 11 plants require no project.

Tabular Data

Tables A_2 through I_2 present data relative to water pollution in the Maumee River Sub-Basin.

Table A_2. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	60[1]	630,140[1]	450,969[1]
Having population data available (Data on pollution load to watercourse incomplete or not available)	25[2]	16,698[2]	Not applicable
Total	85	646,838	--

*Includes incorporated or unincorporated municipalities; other legal bodies such as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

**Includes estimates of industrial wastes discharged into municipal sewerage systems. In some instances the estimates are incomplete.

[1]Includes data for 9 communities which have no comprehensive public sewerage systems. These communities have an estimated combined population of 8,321.

[2]Includes data for 20 communities which have no comprehensive public sewerage systems. These communities have an estimated combined population of 9,849.

Table B_2. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	69**	532,065
Producing organic wastes	16[1]	Undetermined
Producing inorganic wastes	19	Not applicable
Producing wastes of undetermined type	0	--
Total	91[2]	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Includes 12 plants also producing inorganic wastes.

[1]Includes 1 plant also producing inorganic wastes.

[2]Total adjusted to correct for duplication noted in footnotes marked thus, ** and [2].

Table C_2.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	7	5	311,192
Secondary	16	16	240,434
No treatment	62**	--	95,212

*Includes incorporated or unincorporated municipalities; other legal bodies such as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

**Includes 29 communities having no comprehensive public sewerage system, but for which population data are available. These 29 communities have an estimated combined population of 18,170.

Table D_2. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products..	61	16	45	0
Textile mill products.....	1	0	1	0
Paper and allied products..	1	0	1	0
Chemicals and allied products.....	5	1	4	0
Products of petroleum and coal.....	8	5	3	0
Rubber.....	3	1	2	0
Primary metal industries...	1	1	0	0
Fabricated metal products..	8	2	6	0
Miscellaneous.....	3	1	2	0
Total.....	91	27	64	0

*Industries having separate outlets and discharging wastes directly to watercourse.

Table E_2. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	21*	11	9**	1	17	1	3
Industrial	27	10	15	2	17	7	3

* 21 treatment plants serving 23 communities.
** 9 treatment plants serving 11 communities.

Table F_2. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	3	--
1947	0	--	2	--
1948	0	--	3	--
1949	0	--	3	--

Table G_2. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number**	Population served by facilities	Number**
New plant	48[1]	87,510	61[2]
Enlargement or additions to existing plant	9[3]	396,552	14[4]
Replace existing plant	2	3,051	4
No project required	23[5]	158,325	11[6]
Undetermined	1[7]	1,400	1

*The needs as set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these requirements.

**The numerical values representing requirements are based on the number of municipal and industrial sources of pollution. These values may differ considerably from the actual number of projects required because of the possibility of multiple sources of pollution being or becoming tributary to one treatment plant, or because of multiple treatment plants existing or being required at one location.

[1]Includes data for 17 communities which have no comprehensive public sewerage systems. These 17 communities have an estimated combined population of 13,943.

[2]Includes two industries that will discharge their wastes to the new Decatur sewage treatment plant.

[3]Three of these municipalities are served by one treatment plant.

[4]Includes two industries having satisfactory treatment for present needs. Projects are for increased loads expected in the near future.

[5]Includes data for 12 communities which have no comprehensive public sewerage systems. These 12 communities have an estimated combined population of 4,227 for which no treatment is provided. Also includes one community with sewers, but without treatment, and one community with secondary treatment of undetermined adequacy.

[6]Includes two industries having no treatment and one industry having treatment facilities of unsatisfactory design. No treatment projects are considered necessary for these sources at present.

[7]This community has no treatment at present.

Table H_2. Status of treatment works projects to abate pollution, July 1, 1950

Status of project*	Number	
	Municipal	Industrial
No formal action**	34	64
Abatement ordered	1	1
Plans under preparation	11	6
Final plans approved	11***	1
Construction awaiting financing	0	0
Under construction	0	0
Status undetermined	3	8

*Projects required for pollution abatement may have proceeded through several of the stages indicated but are listed only once at the most advanced stage.

**Means that State control agencies have not issued abatement orders or that municipalities or industries have not reached the engineering planning stages for corrective works.

***11 municipalities served by 9 treatment plants.

Table I_2. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served**	Project requirements	Remarks
MICHIGAN			
Manitou Beach	200	New plant	(1)
Morenci	1,845	New plant	Minor pollution effect on Bean Creek. Evidence of need for treatment not conclusive at present.
United Milk Products Co.	--	New plant	Minor pollution effect on Bean Creek. Evidence of need for treatment not conclusive at present.
INDIANA			
Parrott Packing Co.	5,000	New plant	--
Decatur	5,861	New plant	Final plans approved.
Central Soya Company	7,800	Will be tributary to Decatur plant.	--
Moses Dairy	15	Will be tributary to Decatur plant.	--
St. Joseph	437	New plant	(1)
Waterloo	1,257	Replacement	--
Northern Indiana Fuel and Light Company	--	Replacement	Abatement ordered, Phenol wastes.
Cook and Swartz Packing Company	50	New plant	--
Garrett	4,285	New plant	Abatement ordered - Case pending in circuit court.
Avilla	534	New plant	--
Butler	1,794	Replacement	Plans under preparation.
International Harvester Company	--	New plant	Oil wastes; plans under preparation.
Phelps Dodge Copper Products (Inca Division.)	2,530	New plant	Copper wastes; plans under preparation.
Phelps Dodge Copper Products (Indiana Rod and Wire Division.)	--	New plant	Copper wastes; plans under preparation.
Gladieux Oil Sales Co.	--	New plant	Oil and brine wastes.
OHIO			
Antwerp	1,200	New plant	--
Defiance	11,270	New plant	Plans under preparation.
Defiance Canning Co.	20,100	New plant[2]	3,573 cases maximum per day.
Diehl Brewing Company	3,800	New plant[2]	200 barrels per day maximum.
Defiance Milk Products	1,050	New plant[2]	200,000 pounds of milk per day.
Gray and White Company	973	New plant[2]	Mfg. butter-800 pounds of cream per day.
A. C. Pohlman	780	New plant[2]	Slaughter 12 cattle and 12 hogs per day.
Swift and Company	2,600	New plant[2]	Process 250,000 pounds of milk per day. (Cheese and ice cream products).
Western Condensing Co.	81	New plant[2]	Process 300,000 pounds of whey per day.
Central Foundry - GMC	1,090	New plant	--
Napoleon	5,326	New plant	Plans under preparation.
Campbell Soup Co.	--	New plant	Program initiated.
Grand Rapids	655	New plant	--

See footnotes at end of table.

Table I_2. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950--Continued

Name	Population served **	Project requirements	Remarks
OHIO			
Waterville	1,400	Undetermined	--
Glass Fibers Co.	--	New plant	--
Maumee	5,587	New plant	40 percent of wastes tributary to Toledo Sewage Treatment Plant.
Perrysburg	4,039	New plant	Final plans approved.
Interlake Iron	83,732	Additions	Blast furnaces 1275 tons of ore per day; Coke - 1,800 tons per day.
Gulf Refinery	21,160	Additions	40,000 barrels per day.
Toledo Sewage Treatment Plant.	301,372	Additions	Serves 3 municipalities and part of one more-- final plans approved.
Lucas County Sanitary District	Included with Toledo	--	Tributary to Toledo Sewage Treatment Plant.
Ottawa Hills	Included with Toledo	--	Tributary to Toledo Sewage Treatment Plant.
Standard Oil Company	64,630	Additions	--
Goodyear Rubber Co.	323	New plant	Rubber products, pliofilm, plastics, metal plating wastes.
Auglaize Boxboard Co.	18,800	New plant	--
St. Marys Packing Co.	10,070	New plant	Tomato processing wastes.
Vanderhorst Cannery	10,005	New plant	Tomato and tomato products.
Stokely Foods, Inc.	8,320	New plant	Tomato and tomato products.
Mendon	632	New plant	(1)
Rockford	1,066	New plant	--
Sharp Canning Company	14,660	New plant	--
Montpelier	3,800	New plant	--
Montpelier Creamery	--	New plant	--
Edgerton	1,250	New plant	--
Airline Packing Co.	16,500	New plant	Process peas, beans, tomatoes.
Pioneer	755	New plant	--
Edon	630	New plant	--
Edon Produce and Packing Co.	15,000	New plant	Tomato processing.
Schreber Canning Co.	1,200	New plant	Tomato processing.
Wabuck Canning Co.	814	New plant	Tomato processing.
Hicksville	2,644	Enlargement	--
Sherwood	630	New plant	--
Stryker	1,000	New plant	--
Becker Fertilizer Co.	200	New plant	--
Eckert Packing Co.	2,200	New plant	Cattle and hog processing.
Fayette	1,000	New plant	--
Beaverson Slaughterhouse	100	New plant	Winter season only - grease removal.
Fayette Packing Co.	750	New plant	Corn canning-closed 1950.
West Unity	998	New plant	--
Eicher Poultry Co.	725	New plant	Chicken slaughtering.
Archbold	1,487	New plant	Final plans approved.
LaChoy Division, Beatrice Foods, Inc.	1,000	Additions	--
Lugbill Bros. Packing Co.	1,900	Additions	Final plans approved.
Bryan Fertilizer Co.	--	New plant	--

See footnotes at end of table.

Table I_2. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950--Continued

Name	Population served **	Project requirements	Remarks
OHIO			
Bryan Canning Co.....	--	Replacement	Tomatoes and tomato juice.
Bohrer and Moore Packing Co...	440	New plant	--
Walter and Sons Packing Co....	152	New plant	--
Koch Brewing Company.....	73	New plant	--
Oakwood.....	466	New plant	(1)
Spencerville.....	1,830	New plant	--
New Lincoln Highway Dairy.....	117	New plant	--
St. Marys Packing Co.....	4,500	Additions	Tomato canning.
Delphos.....	6,269	Additions	--
St. Marys Woolen Mills.....	8,910	New plant	--
Delphos Fert. and Tankage Co..	100	New plant	--
Republic Creosoting and Riley Tar Company.....	1,200	New plant	--
Cantieny-Strawn Packing Company.....	120	New plant	Meat packing.
Standard Oil Company.....	18,300	Additions	Plans under preparation.
Lima.....	49,425	Enlargement	Plans under preparation.
Sunnydale Cannery.....	--	New plant	Tomato processing.
Kalida.....	521	New plant	(1)
Ada.....	3,629	New plant	Final plans approved.
Cridersville.....	581	New plant	--
Dunkirk.....	922	New plant	(1)
Forest.....	1,083	New plant	(1)
Mt. Blanchard.....	442	New plant	(1)
Kirschner Packing Co.....	10,000	Additions	Plans under preparation.
Findlay.....	23,500	Enlargement	Plans under preparation.
Findlay Provision Co.....	750	New plant	--
Riverside Packing Co.....	1,000	New plant	--
Buckeye Sugar Company.....	43,240	Enlargement	--
Ottawa.....	3,000	New plant	Final plans approved.
Arlington.....	910	New plant	(1)
Ohio Oil Company.....	250	New plant	--
Cooper Tire and Rubber co.....	200	Undetermined	--
Great Lakes Sugar Co.....	34,600	Additions	--
National Refining Co.....	2,800	Replacement	--
Central Steel and Rubber Co...	600	Replacement	Reclaim rubber processing.
Bluffton.....	2,415	New plant	Final plans approved.
Page Dairy.....	904	New plant	--
Tripplett Electric Co.....	--	New plant	Electro plating - small volume.
Pandora.....	800	New plant	(1)
Pandora Canning Company.....	--	Additions	Tomato processing.
Amstutz Cannery.....	190	New plant	Tomato processing.
Middlepoint.....	586	New plant	(1)
Ohio City.....	980	New plant	(1)
Sharp Canning Company.....	8,802	New plant	Tomato processing.
Van Wert.....	10,314	Enlargement	--
Paulding.....	2,344	New plant	--
Continental.....	1,059	New plant	--
Lectrolite Corporation.....	--	New plant	Electroplating - nickel salts and chromic acid.
Foster Canning Company.....	650	New plant	Tomatoes packed whole, juice and products.
Wauseon.....	3,528	Additions	--
Becker and Son.....	100	New plant	Fertilizer (chemical).

See footnotes at end of table.

Table I_2. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950--Continued

Name	Population served**	Project requirements	Remarks
OHIO			
New Bavaria Canning Co.....	--	New plant	Whole tomatoes.
Holgate.....	1,089	New plant	Plans under preparation.
Hamler.....	475	New plant	(1)
Liberty Center.....	787	New plant	Plans under preparation.
Liberty Center Custon Cannery.	--	New plant	--
Delta.....	2,000	New plant	Plans under preparation.
Pet Milk Company.....	1,900	New plant	Evaporated milk. 250,000 - 500,000 pounds of raw milk per day.
Snider Custom Cannery.....	--	New plant	Vegetables packed.
Leipsic.....	1,696	New plant	[1]Final plans approved.
Libby, McNeil and Libby.....	25,300	Additions	Tomato products.
Deshler.....	1,615	New plant	Plans under preparation.
Weston.....	1,200	New plant	[1]Plans under preparation.
Buckeye Canning Co.....	2,380	Additions	Whole tomatoes (planning $NaNO_3$ lagoons).
Swanton.....	1,750	New plant	[1]Plans under preparation.
White House.....	843	New plant	[1]Final plans approved.
Page Dairy.....	1,030	New plant	Cottage cheese mfg., cream pasteurization.
Delta Co-op Food Lockers Slaughterhouse.....	--	New plant	6 hogs; 2 cattle per week.
Sun Oil Company.....	17,500	Additions	60,000 barrels of crude oil per day.

*The needs as set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these requirements.

**Amount of industrial organic waste is reported in terms of population equivalent as measured by B.O.D.

[1]No comprehensive public sewerage system.

[2]While these industrial plants have taken no formal action to abate pollution on an individual basis the State control agency advises that they will, without much question, be connected to the proposed Defiance Sewage treatment plant for which plans are now under preparation.

SANDUSKY RIVER SUB-BASIN

General Description

The Sandusky River Sub-Basin comprises an area of approximately 1,420 square miles in northern Ohio. The sub-basin is roughly triangular in shape with the northern apex on Sandusky Bay where the river discharges to Lake Erie. The river rises in the southeastern part of the sub-basin, flows in a generally westerly direction for about 50 miles, then in a northerly direction for about 90 miles to its mouth. Principal tributaries to the Sandusky River are Tymochtee, Wolf, and Muskellunge Creeks in the western portion of the sub-basin and Broken Sword, Sycamore, Honey and Green Creeks in the eastern portion.

There are no prominent topographic features in the sub-basin. The surface slopes generally from the south side of the area toward Lake Erie and the streams flow in shallow valleys which have been cut into the surface. Soils of the watershed are of glacial origin and some remains of beach deposits left by the receding glacial lake waters are in evidence.

Economic Development

Agriculture, food processing, and manufacturing are the principal industries in the sub-basin. Grain crops are the major agricultural product of the southern part of the watershed, while vegetable crops, to supply the area's processing plants, are produced in the northern part. Meat, sugar, and canned goods are the principal products of the area's food processing industries. Manufacturing activity includes the production of machinery, automobile accessories, furniture, glass, clothing, cutlery, and building materials.

Rainfall and Runoff

The average annual precipitation over the watershed is about 36 inches, with a geographic distribution varying from about 33 inches near Lake Erie to about 40 inches in the headwater areas.

The latest available U. S. Geological Survey "Water Supply Paper" (1948) lists five stream gaging stations in the sub-basin. These stations are located near Fremont, Mexico, Upper Sandusky, and Bucyrus on the main stem and near Havens on a minor tributary. The gaging records show that the average discharge of the Sandusky River at the Fremont station, for a period of record of 22 years (1923-35, 1938-48), was 866 second-feet. The drainage area above this station is 1,248 square miles. The minimum recorded flow of 5.0 second-feet occurred in September 1941.

Major River Developments

The Sandusky River is not developed extensively for commerce, and its only navigational use is by shallow-draft vessels. There is a private hydroelectric power plant at Ballville, about 15 miles above the mouth of the river, with a capacity of 3,000 kilowatts. Upper Sandusky and Tiffin are the sites of small power plants. Water storage sufficient for large scale power production is not available and the available head is so small that hydroelectric power is not generally profitable in this sub-basin.

Population

The 1940 population of the Sandusky River Sub-Basin was approximately 100,800. About half of this population lived in rural areas and communities having populations less than 2,500. The combined 1940 population of the five municipalities now listed as significant sources of pollution was about 48,800.

Water Uses

The Sandusky River is used as a source for domestic and industrial water supplies. The river and tributary streams are also used for livestock water supply and for fishing and other recreation. Four communities use surface streams as a source of all or part of the water for four supply systems serving a combined population of about 45,300. During periods of low, dry-weather flow, the cities of Tiffin and Upper Sandusky consume practically the entire flow of the Sandusky River at their locations.

Sources of Pollution

Five communities with sewerage systems serving a combined population of approximately 48,800 discharge to the streams wastes with a population equivalent of about 25,400. One industrial plant not connected to a municipal sewerage system discharges organic wastes of undetermined amount.

Effects of Pollution on Water Uses

Available data indicate that tributary streams in the sub-basin are little affected by pollution. Parts of the main stem, however, are unsuitable for domestic, industrial or livestock water supply or for game fish propagation. Three of the four surface water supplies of the sub-basin come from streams below sources of pollution. A high degree of waste treatment is required at these sources of pollution to protect the public water supplie particularly during critical low flow periods.

Treatment Provided

Of the five communities listed as sources of pollution, three provide adequate secondary sewage treatment for the domestic wastes from a combined population of about 28,800. The remaining two communities, with sewerage systems serving a population of 20,000, provide no waste treatment. The one industrial plant listed as a pollution source provides some treatment for its wastes, but this treatment is considered inadequate by the State's water pollution control agency.

Treatment Plants Required

New sewage treatment plants are required by the two communities which now do not have treatment facilities. These communities have a combined sewered population of about 20,000. Additions to its present treatment facilities are required by the one industrial source which now contributes a significant amount of pollution to the river.

No waste treatment projects are required by the three municipalities which now provide secondary treatment.

Tabular Data

Tables A_3 through I_3 present data relative to water pollution in the Sandusky River Sub-Basin.

Table A_3. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	5	48,783	25,359
Having population data available (Data on pollution load to watercourse incomplete or not available)	0	--	Not applicable
Total	5	48,783	---

*Includes incorporated or unincorporated municipalities; other legal bodies such as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

**Includes estimates of industrial wastes discharged into municipal sewerage systems. In some instances the estimates are incomplete.

Table B_3. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	0	--
Producing organic wastes	1	Undetermined
Producing inorganic wastes	0	Not applicable
Producing wastes of undetermined type	0	--
Total	1	--

*Industries having separate outlets and discharging wastes directly to watercourse.

Table C_3.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	0	0	--
Secondary	3	3	28,774
No treatment	2	--	28,009

*Includes incorporated or unincorporated municipalities; other legal bodies such as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

Table D_3. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products..	1	1	0	0
Total.....	1	1	0	0

*Industries having separate outlets and discharging wastes directly to watercourse.

Table E_3. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	3	3	0	0	3	0	0
Industrial	1	0	1	0	1	0	0

Table F_3. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	0	--
1947	0	--	0	--
1948	1	6,000	0	--
1949	1	20,000	0	--

Table G_3. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number**	Population served by facilities	Number**
New plant	2	20,009	0
Enlargement or additions to existing plant	0	--	1
Replace existing plant	0	--	0
No project required	3	28,774	0
Undetermined	0	--	0

*The needs as set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these requirements.

**The numerical values representing requirements are based on the number of municipal and industrial sources of pollution. These values may differ considerably from the actual number of projects required because of the possibility of multiple sources of pollution being or becoming tributary to one treatment plant, or because of multiple treatment plants existing or being required at one location.

Table H_3. Status of treatment works projects to abate pollution, July 1, 1950

Status of project*	Number	
	Municipal	Industrial
No formal action**	1	0
Abatement ordered	0	1
Plans under preparation	0	0
Final plans approved	1	0
Construction awaiting financing	0	0
Under construction	0	0
Status undetermined	0	0

*Projects required for pollution abatement may have proceeded through several of the stages indicated but are listed only once at the most advanced stage.

**Means that State control agencies have not issued abatement orders or that municipalities or industries have not reached the engineering planning stages for corrective works.

Table I_3. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
OHIO:			
Upper Sandusky.....	3,907	New plant	--
Tiffin.....	16,102	New plant	Final plans approved.
Great Lakes Sugar Co.....	--	Additions	Abatement ordered.

*The needs as set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these requirements.

CUYAHOGA RIVER SUB-BASIN

General Description

The Cuyahoga River Sub-Basin comprises an irregularly shaped area of 813 square miles in northeastern Ohio. The Cuyahoga River flows from its headwater area in a generally southwesterly direction for about 45 miles, then westerly for about 12 miles to its confluence with the Little Cuyahoga River, and then in a generally northerly direction for about 40 miles to its mouth on Lake Erie at Cleveland. Major tributaries to the Cuyahoga River are Tinkers Creek, Little Cuyahoga River, and Congress Lake Outlet.

The terrain of the sub-basin consists generally of rolling hills. The greatest part of the soil of the region is of glacial origin. Parts of the area are poorly drained and numerous small lakes and ponds exist.

Economic Development

Manufacturing and agriculture are the principal industries in the region. Manufacturing activities in the sub-basin are concentrated in the vicinities of Cleveland and Akron. Primary metals, machinery and metal products, chemicals, wearing apparel, and food products are manufactured or produced in substantial quantities in the Cleveland area, and the manufacture of rubber and rubber products is of primary importance in the vicinity of Akron.

The principal agricultural activity in the watershed is dairy farming. The soils are best suited for the production of stockfeed. Some fruit is grown in the northern part of the sub-basin and cranberries are produced in some of the swampy areas which are scattered throughout the watershed.

Rainfall and Runoff

The normal annual precipitation over the watershed is about 35 inches. The normal monthly precipitation is fairly uniform throughout the year, varying from a low of about 2.3 inches in February to a high of about 3.6 inches in July.

Records for the Geological Survey gaging station at Independence, Ohio, show that the average flow of the Cuyahoga River for a period of record of 17 years (1921-22, 1927-35, 1940-48) was 683 second-feet. The drainage area above this station is 709 square miles. The minimum combined discharge of the river at this station and the parallel Ohio Canal was 48 second-feet and occurred in August, 1933.

The Geological Survey currently maintains six gaging stations in operation in the sub-basin. Three of these stations are on the main stem and three on tributaries.

Major River Developments

The lower 5-1/4 miles of the Cuyahoga River have been improved for commercial navigation. The channel is maintained at a depth of 21 feet. The entire length of the improved section of the river is within the influence of Lake Erie so navigation is not affected by low flows.

The Ohio Canal, which paralleled the Cuyahoga River from Akron to Cleveland, was a water transportation route from the Ohio River to Lake Erie in the early part of the 19th Century. This canal is no longer used for transportation, but sections in Akron and Cleveland serve as channels for industrial water supply and storm water flow.

The largest water power development in the sub-basin is located on the Cuyahoga River at Cuyahoga Falls. This plant has an installed capacity of about 1,950 kilowatts and an available head of 105 feet. There are two other plants having capacities of 149 and 225 kilowatts. Three major water supply reservoirs are located in the sub-basin. One of these reservoirs, located on the Little Cuyahoga River just above Mogadore, supplies raw water to industries in Akron. Lake Rockwell Reservoir, located on the Cuyahoga River just upstream from Kent, is the principal water supply source for the City of Akron. This reservoir alone has capacity to supply an average of 35 million gallons per day to the city. The third reservoir is located in the headwater area on the East Branch of the Cuyahoga River and regulates river flow to the Lake Rockwell Reservoir. At the time that it was built it was estimated that this reservoir would increase Akron's water supply storage capacity to the extent that it could supply 40 million gallons per day.

Population

The 1940 population of the sub-basin (exclusive of that portion of Cleveland which lies within the watershed) was approximately 402,700. The 1940 population of the entire

city of Cleveland is included in the 1940 population of the Lake Erie Shore Line Sub-Basin. It is estimated that the 1940 population of that portion of Cleveland which actually lies within the Cuyahoga Sub-Basin was approximately 474,000.

The 1940 population of all municipalities now considered significant sources of pollution, exclusive of that portion of Cleveland which lies within the sub-basin, was approximately 350,200. The 1940 population of the entire city of Cleveland is included in the 1940 population of sources of pollution in the Lake Erie Shore Line Sub-Basin. This population figure does include, however, the 1940 populations of the 13 communities outside Cleveland which are tributary, all or in part, to the Cleveland Southerly sewage treatment plant.

Water Uses

The streams of the watershed are used for domestic, industrial and livestock water supplies, for navigation, power generation, waste disposal, and recreation. Two municipal water supplies which use surface water as a source serve a combined population of about 256,000 in four municipalities. Considerable use is made of the navigation facilities of the lower portion of the river. In 1940 more than 8-1/2 million tons of freight were carried by vessels using the river. Water power developments in the watershed have a combined installed capacity of about 2,500 kilowatts. Streams of the sub-basin are used for final disposal of wastes from 29 municipalities and from 56 industries which have private outlets to the streams.

Sources of Pollution

Domestic wastes from a sewered population of about 750,600 in 29 communities are discharged to the streams of the watershed. Wastes discharged to watercourses by a combined population of about 748,900 in 27 communities have a population equivalent of about 271,000. Population equivalent data for wastes discharged from a population of 1,700 in 2 communities have not been obtained.

A total of 56 industrial plants contribute significant amounts of wastes to the streams through private outlets. Twenty-eight plants contribute organic wastes with a population equivalent of about 79,000. Of these, only 10 produce organic industrial wastes and the remaining 18 produce organic wastes which are sanitary wastes only. Sanitary sewage is the only significant waste discharged from one of these 18 plants. Population equivalent data for the organic industrial wastes from 13 plants have not been obtained. Thirty-two plants produce inorganic industrial wastes, 26 of which also produce organic wastes. Of these 26 plants, nine produce organic industrial wastes, while the only organic wastes from the remaining 17 plants are sanitary wastes with a known combined population equivalent of 6,600. The types of wastes produced by nine plants have not been determined.

Available data show that a known combined domestic and organic industrial waste load with a population equivalent of about 350,000 is discharged to the watercourse. Of this total for the entire sub-basin, domestic and organic industrial wastes with a known population equivalent of about 285,000 are discharged to the lower 12.5 miles of the Cuyahoga River. In addition, 5 of the 13 industrial plants which produce an undetermined organic waste load, and 18 of the 32 plants which produce inorganic wastes, discharge their wastes to this same portion of the river.

Effects of Pollution on Water Uses

Stream pollution apparently has no detrimental effects on the two surface water supplies in the sub-basin. No significant pollution sources exist upstream from one water supply source and the treatment provided at sources of pollution located upstream from the other water supply are subject to supervision by the city which uses water from the source reservoir.

The State water pollution control agency has listed much of the main stream as being unsatisfactory for industrial or livestock water supply or for game fishing as a result of upstream pollution. The same conditions exist in portions of the major tributaries and, to a lesser extent, in some minor tributaries. The recreational value of a number of public parks in the metropolitan Cleveland area has been reduced by the pollution of the streams which flow through them.

Treatment Provided

Tables C_4, D_4 and E_4 contain data relative to waste treatment now accomplished in the sub-basin. Six secondary treatment plants serve a total population of about 600,500 in 18 communities and parts of two more communities. Five primary treatment plants serve a total population of about 47,200 in five communities. Wastes from a population of about 103,000 in two communities and parts of two more communities receive no treatment. Wastes from 15 of the 56 separate industrial waste sources in the sub-basin receive some kind of treatment, while wastes from 35 receive no treatment. The status of waste treatment at six industrial waste sources is undetermined. Six of the 11 existing municipal treatment plants and six of the 15 existing industrial treatment plants are considered inadequate by the State water

pollution control agency. The adequacy of four industrial treatment plants is undetermined.

Treatment Plants Required

Table G_4 presents data relative to tentative waste treatment plant requirements in the sub-basin. Municipal requirements are: four new plants or collection facilities, six enlargements or additions to existing facilities to serve twenty communities or parts of communities, and two replacements of existing facilities. Three municipalities require no waste treatment projects at this time.

Table A_4. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	27[1]	748,856	271,045
Having population data available (Data on pollution load to watercourse incomplete or not available)	2[2]	1,732[2]	Not applicable
Total	29	750,588	--

*Includes incorporated or unincorporated municipalities; other legal bodies such as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

**Includes estimates of industrial wastes discharged into municipal sewerage systems. In some instances the estimates are incomplete.

[1]These 27 population centers include only 23 separate entities and a part of Cleveland. The portion of Cleveland tributary to this sub-basin is considered as two population centers and each of two other municipalities is considered as two population centers. This breakdown is made for convenience in tabulating data because of the division of the municipalities into separate sewer districts.

[2]Includes data for one community which has no comprehensive public sewerage system. This community has an estimated population of 932.

Table B_4. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	28**[1]	79,011
Producing organic wastes	13[2]	Undetermined
Producing inorganic wastes	32	Not applicable
Producing wastes of undetermined type	9	Undetermined
Total	56[3]	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Includes 18 plants whose only organic wastes are sanitary wastes. These sanitary wastes have a combined population equivalent of about 6,666. Sanitary waste is the only significant waste of any kind from one of these plants.

[1]Includes 21 plants also producing inorganic wastes.

[2]Includes 5 plants also producing inorganic wastes.

[3]Total adjusted to correct for duplication noted in footnotes marked thus, [1] and [2].

Table C_4.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	5	5	47,170
Secondary	20	6	600,486
No treatment	4**	--	102,932

*Includes incorporated or unincorporated municipalities; other legal bodies such as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

**Includes data for one community having no comprehensive public sewerage system. This community has an estimated population of 932.

Thirty-two industrial plants require new waste treatment facilities, four require enlargements or additions to existing facilities, four require replacement of existing facilities, six require no projects, and the treatment plant requirements of ten are undetermined.

Tabular Data

Tables A4 through L4 contain data relative to water pollution in the Cuyahoga Sub-Basin.

Table D_4. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products.	5	0	5	0
Textile mill products.....	1	0	1	0
Paper and allied products.	3	0	3	0
Chemicals and allied products.....	9	3	6	0
Products of petroleum and coal.....	7	5	2	0
Rubber products.....	6	--	--	6
Leather and leather products.....	1	0	1	0
Primary metal industries..	12	5	7	0
Fabricated metal products.	6**	2	4**	0
Miscellaneous.....	6	0	6	0
Total.....	56	15	35	6

*Industries having separate outlets and discharging wastes directly to watercourse.
**One plant provides treatment for sanitary wastes only.

Table E_4. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	11*	5	6**	0	9	2	0
Industrial	15	5	6	4	11	0	4

* Eleven plants serving 25 municipalities.
** Six plants serving 20 municipalities.

Table F_4. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	0	--
1947	0	--	0	--
1948	0	--	0	--
1949	0	--	0	--

Table G_4. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number**	Population served by facilities	Number**
New plant	4[1]	102,932	32
Enlargement or additions to existing plant	20[2,3]	628,570	4
Replace existing plant	2	15,800	4
No project required	3	3,286	6[4]
Undetermined	0	--	10[5]

*The needs as set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these requirements.

**The numerical values representing requirements are based on the number of municipal and industrial sources of pollution. These values may differ considerably from the actual number of projects required because of the possibility of multiple sources of pollution being or becoming tributary to one treatment plant, or because of multiple treatment plants existing or being required at one location.

[1]Includes one community which has no comprehensive public sewerage system. This community has an estimated population of 932.

[2]Sixteen of these municipalities are served by two treatment plants: Part of Cleveland and 13 more smaller municipalities are served by one treatment plant, and Akron and one other municipality are served by one treatment plant.

[3]Includes 2 municipalities with treatment plants which are considered satisfactory at present; additions required are for expected load increases in the near future.

[4]Includes one industry which, though not having treatment facilities, will not require treatment in the near future.

[5]Includes 2 industries providing no treatment of wastes, but for which project requirements are as yet undetermined.

Table H_4. Status of treatment works projects to abate pollution, July 1, 1950

Status of project*	Number	
	Municipal	Industrial
No formal action**	6	49
Abatement ordered	0	0
Plans under preparation	1	0
Final plans approved	16[1]	1
Construction awaiting financing	0	0
Under construction	2[2]	0
Status undetermined	1	0

*Projects required for pollution abatement may have proceeded through several of the stages indicated but are listed only once at the most advanced stage.

**Means that State control agencies have not issued abatement orders or that municipalities or industries have not reached the engineering planning stages for corrective works.

[1]Includes population centers listed in table I as being tributary to Cleveland plant.

[2]Includes Mogadore which is tributary to the Akron plant.

Table I4. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served**	Project requirements	Remarks
OHIO			
Mantua	870	Additions	--
B. & O. R.R. Yards	--	New plant	--
Kent Laundry	--	New plant	--
Perfection Dairy	125	New plant	--
Gongler Machine Co.	170	New plant	--
Lamb Electric Company	350	New plant	--
Portage Plating Co.	--	New plant	--
Kent	15,000	Replacement	Final plans approved.
The Monroe Falls Paper Company	--	Undetermined	--
Cuyahoga Falls	20,000	Additions	--
Akron	284,000	Additions	Under construction.
Mogadore	Included with Akron	--	Tributary to Akron Sewage treatment plant.
Cuyahoga County Sanitary District	800	Replacement	--
The Jaite Company	--	New plant	--
Cleveland (Part)--Southerly Sewage Treatment Plant	301,000	Additions	Final plans approved.
Garfield Heights	(1)	--	(2)
Linndale	(1)	--	(2)
North Randall	(1)	--	(2)
Parma	(1)	--	(2)
Parma Heights	(1)	--	(2)
Seven Hills	(1)	--	(2)
Warrensville	(1)	--	(2)
Brooklyn	(1)	--	(2)
Brooklyn Heights	(1)	--	(2)
Brook Park	(1)	--	(2)
Cuyahoga Heights	(1)	--	(2)
Newburgh Heights (Part)	(1)	--	(2)
Maple Heights (Part)	(1)	--	(2)
Newburgh Heights (Part)	--	New facilities[4]	Collection necessary for wastes now discharged directly to stream.
Maple Heights (Part)	2,000	New plant	--
American Steel and Wire Company	--	New plant	--
Burdett Oxygen Co.	--	Additions	--
River Smelting and Refining Company	15	New plant	--
West Works of Aluminum Company of America	1,300	New plant	--
Harshaw Chemical Co.	441	New plant	--
Cuyahoga Soap Company	--	New plant	--
Elco Lubricant Company	15	New plant	--
Stadler Products Co.	--	Additions	--
Plumer Leather Company	1,300	New plant	--
Republic Steel Corp. 98 inch Strip Mill	900	New plant	--
RFC/ODP Blast Furnaces	50	Undetermined	--
Jones & Laughlin Steel Co. Coke Plant	8,500	Replacement	--
Tar Distilling Co.	--	Undetermined	--
Reilly Tar & Chemical Company	--	New plant	--

See footnotes at end of table.

Table I_4. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950--Continued

Name	Population served**	Project requirements	Remarks
OHIO			
Republic Steel Corp. Corrigan McKinny Works	1,400	New plant	--
Republic Steel Corp. Blast Furnaces	225	Replacement	--
E.I. du Pont de Nemours	470	New plant	--
Standard Oil Company Refinery No. 1	--	Additions	Final plans approved.
Sherwin Williams Co. (Linseed oil)	--	New plant	--
Sherwin Williams Co. (Paints)	--	New plant	--
Siegfried Lowenthal Co	30,000	New plant	--
Refuse Incinerator (City of Cleveland)	--	New plant	--
Republic Steel Corp. Bolt & Nut Works	500	New plant	--
Cleveland (Part) Low-Level Area	--	New plant	Plans under preparation.
Middlefield	932	New plant	[3]
The Johnson Rubber Co	30	New plant	--
Smallwood Packing Co	1,300	New plant	--
Romito-Donnelly Company	--	New plant	--
Vale-Edge Dairy	240	New plant	--
Annevar Mills	--	New plant	--
Ravenna	10,500	Additions	--
General Tire & Rubber Company	--	Undetermined	--
Goodyear Tire & Rubber Company	--	Undetermined	--
Firestone Tire & Rubber Company (Synthetic)	--	Undetermined	--
Goodrich Tire & Rubber Company (1)	--	Undetermined	--
Firestone Tire & Rubber Company (Main plant)	--	Undetermined	--
Goodrich Tire & Rubber Company (2)	--	Undetermined	--
Quaker Oats Company	--	Undetermined	--
Phillips Paper Company	700	New plant	--
Bedford	12,200	Additions	--
Allied Chemical & Dye Corporation	75	Additions	--
New York Central R. R.	--	New plant	--
Fanner Mfg. Company	275	New plant	--
Darling & Company	--	New plant	--
American Steel & Wire Co., Coke Plant	17,000	Replacement	--
American Steel & Wire Co., Newburgh Works	--	Replacement	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these requirements.

**Amount of industrial organic waste is reported in terms of population equivalent as measured by B.O.D.

[1]Population served data included with figure for Cleveland Southerly Sewage Treatment Plant.

[2]Tributary to Cleveland Southerly Sewage Treatment Plant.

[3]No comprehensive public sewerage system.

[4]For purposes of tabulation in Table G_4, this municipality has been included with "New plants".